COLOUR·HARMONY AND·CONTRAST

BY

JAMES WARD.

Decoration

COLOUR HARMONY AND CONTRAST

Portion of the Lions Frieze from the Ancient Persian Palace at Susa.

V. BROOKS, DAY & SON, LTD., LITH.

COLOUR HARMONY AND CONTRAST

FOR THE USE OF

ART STUDENTS, DESIGNERS, AND DECORATORS

WITH SIXTEEN PLATES IN COLOUR, AND ELEVEN EXPLANATORY DIAGRAMS

By JAMES WARD

AUTHOR OF 'PRINCIPLES OF ORNAMENT,' 'HISTORIC ORNAMENT,' 'PROGRESSIVE DESIGN,' ETC.

SECOND EDITION

LONDON: CHAPMAN AND HALL, LTD.

1912

PREFACE

THE aim of the writer in this work has been to treat the subject of colour, both in its physical and artistic aspects, and also to show the connection, as well as some of the distinctions, between the scientific theory of the spectral colours of light, and the artistic practice of colour harmony and contrast. The book may also be described as the result of an attempt to provide a practical colour manual for the use of art students, decorators, and designers, and for those who may be engaged in any occupation where a knowledge of colour is essential.

It is common enough to hear it said, that colour cannot be taught; this is, however, an erroneous idea, for those who have studied and practised in this subject affirm, with the late William Morris, that colour can be taught.

We might point out to the unbelievers in colour-teaching, that certain colour arrangements which are harsh and discordant may be changed, or altered to agreeable combinations, by any one who has a knowledge of the laws of colour harmony, and it is a matter of fact that the great colourists were usually the pupils of masters who enjoyed the reputation of being the best colourists of their time.

We are indebted to many distinguished modern scientists for works written on colour, in which the physical

side of the subject has received the greatest attention, but in which works are also embedded many valuable hints in the artistic use of colour. In this direction we confidently recommend to the reader's notice the works on colour written by Professor Ogden Rood, Professor Church, and Sir William Abney.

The student of ancient and medieval history learns that colour was lavishly used in the art, and in the every-day life of the people in those days, and we all know that colour is the life of nature, but we do not profit from this knowledge as much as we ought. The public use of colour in England of to-day is, generally speaking, confined to the scenic effects of the theatre, to the picture gallery, to a coronation, or to an occasional display of fireworks, and if it were not for the generous efforts of the bill-poster to provide us with the "poor man's picture gallery" on the suburban hoardings, our great manufacturing towns would be entirely colourless, and our street life would be reduced to the monotonous level of a black and white exhibition. We must admit, however, that many signs of a freer use of colour in modern life are now apparent; one of the most noteworthy is the development of coloured illustrations in books and magazines, also the evolution of the new process of trichromatic photography and three-colour printing, and we sincerely hope, with Mr. Mortimer Mempes, that the day is not far distant when we shall be able to purchase our weekly illustrated papers with all the illustrations produced in colour.

J. Ward.

CONTENTS

LIST OF PLATES

COLOUR HARMONY AND CONTRAST

CHAPTER I

THEORY OF LIGHT—THE SOLAR SPECTRUM AND THE PRODUCTION OF COLOURED LIGHT BY DISPERSION—COLOUR PRODUCTION BY ABSORPTION, BY DIFFRACTION, AND BY INTERFERENCE

THE sensation which we call light is produced by the action of luminous rays on the retina of the eye, propagated or emitted from self-luminous bodies, as the sun, the arc, and incandescent electric light, the flames of gas, and candles, etc. Light is also produced, in a lesser degree, as a sensation to the eye, from non-luminous bodies when they are illuminated by any of the above self-luminous bodies, and the illumination thus reflected by the former is borrowed light.

Light is conveyed in undulations or waves in the medium known as luminiferous, or light-bearing ether, a medium whose elasticity and subtility is inconceivable, and

that exists everywhere, pervading all space and matter. It is said to be present in all liquids, gases, solids, and even in vacuums. It is generally assumed by scientists that light is originated by the particles, or molecules, of a luminous body, which being in an intensely active state of never-ending and oscillating motion, communicate their activity to the imponderable ether, and the delicate, but active, motion of this mysterious medium, with the molecules of the luminous body oscillating up and down in it, like corks in rippling water, but not travelling in any one direction, when communicated to the eye, produces the sensation of light.

The luminous ether waves which make up the composition of light have varying lengths and motions, the shortest and the quickest being those which produce the violet colour sensation of the spectrum, and the longest and slowest being those that produce the red sensation. The orange, yellow, green, and blue sensations are composed of other distinguishing wave-lengths, which have corresponding relative rates of motion.

White light, or ordinary daylight, is therefore compound in character, being composed of an innumerable number of varying wave-lengths, or *colours*—for a colour is determined by its wave-length—and, conversely, a mixture of the spectrum colour rays generates the sensation of white light. If the solar light was simple in character, and incapable of being decomposed into the colours of the spectrum, then every coloured object, when

seen, would reflect to the eye its image in black and white only, or, in other words, we should see the object simply in light and shade.

THE SOLAR SPECTRUM.

We owe the discovery of the prismatic spectrum to Sir Isaac Newton, who by means of a triangular glass prism was able to practically demonstrate the compound nature of solar light, and to analyze it into its component parts. Newton's experiment may be briefly described as follows—A small beam of sunlight is allowed to enter a darkened room through a hole or slit in the window shutters, as at S, Fig. 1, and a triangular glass prism is arranged as at P, with the horizontal base upwards, and in the illuminated path of the sunbeam, S S′; a white sheet or screen is placed about fifteen feet from the prism, and the rays of light enter the prism at point X, where they are refracted, or bent back, as they pass through the prism and are dispersed in an opened-out form, where they emerge from the opposite side of the prism into a band of rainbow-coloured light, and this band is impinged on the white screen opposite. The band of colour, R, O, Y, G, B, V,

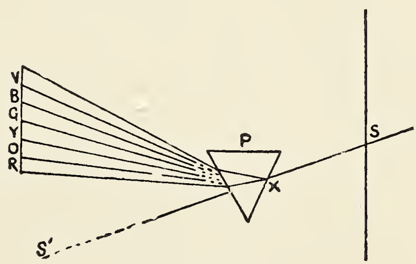


FIG. 1

Fig. 1, can now be examined. At one end is seen a dark red or deep crimson hue going into a more brilliant red, the latter developing into orange; this colour again changes into a yellowish-green rather rapidly, on account of the intermediate yellow occupying a very small space on the spectral band; the yellowish-green develops as we advance into pure green, this in turn shades off into blue, through intermediate stages of blue-greens, the full blue is not as bright as the green, and its effect on the eye is not so exciting as the latter colour; the blue gradually gives place to the last colour sensation of the spectrum, that of violet, this colour being the least bright of the spectral hues. (See diagram of the spectrum at Fig. 2.)

Purple is a colour sensation which is not found in the prismatic spectrum, as it cannot be produced by one set of wave-lengths, but is a mixture of red and blue, or red and violet waves. It will be seen that although there is almost an infinite number of hues or colours from red to violet in the spectral band, it has been found convenient to select the six principal ones, and to give them the names of red, orange, yellow, green, blue and violet.

Just as the solar light may be divided by means of the glass prism into its constituent parts, which results in the production of colour, so may this coloured light be recomposed into the original white light by arranging a second prism with its refracting angle in an opposite position to that of the original prism, placed very near to the latter, and nearer the screen, when the beam of coloured light

will pass through the second prism and emerge as a recomposed beam of white light. Another—Newtonian—experiment for the recombination of colours into white, consists in painting sectors of a circular disc of cardboard with the principal colours of the spectrum, and by causing the disc to whirl with great rapidity, like a spinning-top ; the colours blend themselves into a resulting white of a low luminosity or pale grey. Three colours only may be used to paint the sectors, namely, red, represented by a bright vermilion ; emerald-green, and ultramarine blue ; the space on the disc for the blue should be about one-sixth less than that for the red, and the green should occupy a space that will be a mean proportion between the red and blue.

A disc painted in the above manner and rapidly spun or whirled will produce white or pale grey, but, practically, in any case, an absence of any chromatic colour sensation is caused by the mingling of the colours of the painted sectors on the retina of the eye, which are thus blended in a physiological sense, and not in a physical one. Pairs of colours, such as yellow and blue, or red and blue-green, may also be arranged as sectors to produce the same result, their proportions being determined by experiment. These mixtures will be further considered in Chapters IV and V.

COLOUR PRODUCTION BY ABSORPTION, BY DIFFRACTION, AND BY INTERFERENCE.

Within the mechanism of the nerve tissue of the human eye the vibratory movement of the luminiferous ether is rearranged in accordance with the reflection of the latter from a visible object, and the nerve tissue vibrates in unison with the vibrations of light, or of what constitutes light; on this depends the sense of all accurate vision. Therefore, when an object or body appears of distinct colour to the eye, say red, for example, then broadly speaking the wave-lengths of red are transmitted to the retina of the eye to the exclusion of other coloured rays, and the light which illuminates the red object has nearly all of the other coloured rays of its composition absorbed or quenched by the red rays, so that, in this case, a sufficient quantity of red rays are reflected from the coloured object, which gives the sensation of red to the eye. This example, however, can only be considered as an illustration of what is approximately true, for the inherent colours of natural or artificial objects are never absolutely pure from a scientific standpoint, but are mixed, more or less, with the colours which come next to them in point of wave-length; also, a colour is said to be *pure* when it is free from a mixture of white light, and consequently the most brilliant colours of natural or artificial bodies, including artists' pigments, when viewed, always must reflect a certain amount of

white light from their surfaces in addition to their own particular colour, and some of this white light, reaching the eye, is mixed with the colour of the object and so lowers its chromatic purity. Coloured bodies, as we have seen in the case of the red object, possess the power of absorbing all coloured rays except those of their own colour, and so their colour is due to what is known as *Selective Absorption;* for example, when a red object is seen in daylight, a certain portion of the light enters into the colour, and nearly all the yellow, green, blue, and violet rays of the white light will be absorbed, and as the red rays are not absorbed the predominant colour of the object is thus determined.

In the case of a dull black there is little or no reflected light sent to the eye, also, black, being in a chromatic sense the negation of colour, does not possess any powers of *selective* absorption, but absorbs or quenches all coloured rays alike, and conversely, such substances which do not absorb any coloured rays in a selective sense, but reflect all, or nearly all the light they receive unchanged, to the eye, appear white. Greys, like white, do not absorb coloured rays of light, their tones being determined simply by the amount of reflected light they send to the eye.

Colours of paints, or indeed the colours of any natural bodies, described as red, green, etc., are not, accurately speaking, red or green, but are mixtures in which these colours predominate, for when tested by the red or green of the spectrum they are found to be a mixture of various

colours in which the red or green, as the case may be, exists as the dominant hue.

Some of the richest and purest colours at our command are those found in the best kinds of stained glass and enamels, and yet these, when compared with the spectrum colours, are far from approaching the intensity and saturation of the prismatic hues. According to Professor Ogden Rood, the author of *Modern Chromatics*, the red colour transmitted through a piece of red glass when tested by the spectrum had a good deal of orange rays, a little green, and still less blue; also, the transmitted red light was only half as great in luminosity as the red of the spectrum. Orange-coloured glass transmitted red, orange, and yellow rays, also green, and a little of the blue rays; here the green and red rays, however, mixed to produce an orange-yellow (an illustration that yellow is a compound colour), but the final colour was orange-yellow, without any trace of red or green. Green glass showed a good deal of the green light, but had also some blue and a little red, and blue glass in addition to its colour had in its composition a good deal of violet, a little green, and lesser portions of yellow and red.

These analyzed examples of the colours, known as vitreous oxides, used in glass-staining and painting, and in enamels, although being the richest that can be employed in decorative art, show themselves inferior in purity and luminosity to the hues of coloured light, and the pigments used by artists and by dyers are considerably lower still in purity

from the scientist's point of view. For all practical purposes, however, of everyday life, artists, decorators, and dyers have at their command a wide range of colours that are brilliant and pure enough for their purposes, in fact some of the aniline dyes produced from coal-tar products that are now so extensively used in textile dyeing, furnish a wide selection of startling and undesirable colours which are useless to the artist on account of their changing and fugitive qualities.

An easy and simple experiment may be made to show the production of colour, and at the same time a change of colour, by the thickening of the absorbing medium. If a piece of blue glass—selected as pure in colour as possible—be held up to the light from a window, and another piece of the same colour placed over a portion of this, the transmitted light through the double thickness of glass will appear a violet-blue, and if a third piece is placed over the other two the light will not only be further darkened, but the new colour will have a still greater proportion of red rays, making the resulting colour a deep violet; four, five, or six thicknesses will proportionately augment the red rays until almost a dark purple is reached.

Slips of red glass used in the same way will produce first a deep crimson, and according to the number of pieces used over each other, the tones of colour will deepen into dark purples.

Yellow glass will deepen first into orange, next, to a deeper orange, approaching more to red, as the successive

layers of glass are placed over each other. Green slips of glass do not show such a marked change of colour, as in the other examples, when placed over each other in layers, but darken gradually into a deep olive-green, the darkest effects being similar to those produced by mixtures of yellow and black.

It will be seen that the colours under notice, when darkened by the successive layers of similar coloured slips of glass, gain, not only in depth of tone, but, eventually, though gradually, change in hue; it follows from this that artists and decorators, when they wish to darken or shade such things as drapery or ornament in their work, ought to select similar tones to produce a true and natural result in the colour of the shadows. Thus, for instance, the shading colours required for a yellow drapery would be more orange in hue than those required for the mere darkening of the original yellow—called by artists the "local" colour—and the deeper shadings would incline more to an amber-red; the high lights on yellow draperies would also require a little red in their mixture of yellow and white to prevent them from becoming too cold. Of course the artist will make modifications in the colours of his draperies and other portions of his work, in accordance with the coloured light that would be reflected from the different hues of adjacent objects in the picture, but, on the whole, it must be admitted, that he can learn a good deal from this peculiar changing of colour which is due to the thickening of the absorbing medium. These effects are in perfect accordance with

the colour harmony, known as the "small interval," which will be explained hereafter.

The peculiar changes of colour above mentioned, are not only common to stained glass, but to many pigments used by artists, especially those colours that are more or less transparent in body, such as Prussian and Antwerp blues, crimson lake, and the madders, gamboge, brown-pink, etc. It is well known that these colours, when in the solid or dry state, present totally different and much darker hues than when they are spread out moderately thin on a white ground, when used as water-colours, or mixed with a white pigment as in oil-painting, and in fact the proper hues of these pigments are only determined when they are mixed with a small quantity of white, obtained in water-colour by the white of the paper reflecting through the wash of the colour, and in oil-colour by the addition of opaque white, or by thinning out the pigment with oil or varnish, and spreading it over a non-absorbent white ground. It may be said, therefore, that these pigments are changed in hue, in accordance with the thickening of the absorbing medium, to darker shades, and only show their purest hues when they reflect a sufficient proportion of coloured light which determines their highest degree of luminosity or brightness. This is precisely the case of the examples in the colours of the stained glass we have just noticed.

Certain pigments that are opaque in body, such as the chrome yellows, emerald-green, and vermilion, show more purity of colour when they are mixed with water than

when they are seen in a dry state, and appear still deeper and purer when mixed with oil or varnish. This is accounted for by the fact that the dry and dense surfaces of these pigments reflect much more white light, mixed with their coloured light, than is reflected by the same pigments from their wet, and consequently darker surfaces, and this is in agreement with the theory, mentioned before, namely, that a colour is richer and more pure when it reflects little or no white light.

In oil-paintings the colours usually appear richer than those seen in water-colour paintings, and a greater depth of colouring may be obtained in water-colours than in tempera paintings, or fresco, but for brightness or luminosity, in an artistic sense, none of the above varieties of painting can equal that of pastel-painting.

This quality of brightness, possessed by pastel-paintings, is due to their dense mat or "dead" surface, in which there is an entire absence of anything of a "shiny" nature, and which causes them to reflect much more light than any other variety of pictorial work; this also accounts for the fact that pastels possess a kind of self-illumination which makes them show up better in a badly-lighted room than any other kind of paintings. Fresco-paintings—those of the genuine variety, known as *fresco-buono*—come next to pastel-painting in point of artistic luminosity, their luminous quality being also due to their mat surfaces, and their power of reflecting light, and is further helped by the semi-transparent method adopted by artists when using the

purer, or more deeply saturated colours, in the half-tones and shadows. Spirit-fresco paintings, and other imitations of *fresco-buono*, are inferior to the latter in luminosity.

We shall now consider the dispersion of light known as *diffraction*, and the production of colour by diffracted light. When from a brightly-illuminated source a beam of light passes by the edges of an opaque body, or, say, through a fine slit made in a piece of blackened cardboard, the rays from the beam of light are diffracted, or in other words they are bent out of their straight or direct course, on either side of the slit, and this bending back disperses them into a series of spectra with all their ranges of beautiful colours. Thus at the angles of the opaque body the waves of light are bent according to their different degrees of refrangibility, the action being similar to that of the waves of water turning sharply round the exterior angle of a wall. Diffraction colours may be seen by holding up before a bright point of light a bird's feather, a piece of wire gauze, a thin bit of cambric, muslin, or silk. A very simple and effective method may be recommended to the student who wishes to see for himself an illustration of colour production by diffracted light; a thin piece of cardboard, three or four inches square, should be painted on both sides a solid dull black, and through the middle of the cardboard an incision, about two inches in length, should be made with a very sharp pocket-knife, so that the fine slit thus made may be clean cut, without ragged edges, and not much more than a hair's-breadth in

width; a lighted candle is placed in a darkened room, or is used at night for the experiment, and the flame of the candle is viewed through the slit in the blackened card-board, which must be held close to the eye and at a distance of three or four feet from the candle, when the flame of the candle will appear a bright yellow spot in the centre, but on either side of it will be seen a series of beautiful spectra diminishing in size, and each separated by a narrow black vertical band.

Colour production by diffraction is closely allied to the production of colour by the *interference* of light-waves with one another, and by what is known as the *polarization* of light. To produce colour effects by the latter agency it is necessary to employ a polarizing apparatus known as the *polariscope*, under which the crystals of certain acids and salts, as tartaric acid, nitrate of potash, etc., or thin plates and scales of certain minerals, such as selenite, show some of the most wonderful combinations of colours in some cases, and in others brilliant patches of single colours of marvellous and dazzling beauty, that belong entirely to fairy-land of science, and are hardly met with in other domains of nature.

The natural laws, however, that govern the production of colour by polarization are similar, in a great extent, to those that produce what are called "interference colours."

The term "interference," or interposition of the waves of light, was first used by Dr. Young to express the phenomena resulting from the action of these waves on

each other. It is based on, and is in accordance with, the undulating theory of light, and helps in a great measure to prove that theory. Interference presents many complex features, but the main idea is this: when two *pencils*—or small groups of parallel rays—of light, emitted from two different luminous points, making an exceedingly small angle with each other, meet on the surface of an object, they will *interfere* with each other and so produce certain differences of colour, or other effects, according to the wave-lengths of the rays contained in the pencils of light; in some instances they intensify the illumination, in others they produce black or dark grey, while in other cases brilliant colours of every imaginable hue are created.

In the two cases of colour production by polarization and interference, the same kind of action takes place, namely, a sifting process is set up amongst the constituents of white light, and certain rays are eliminated or struck out, the result being a production of colour.

Interference colours are only seen when the objects so coloured are exceedingly thin in substance, such as a thin layer or film of metallic oxide, water, air, glass, oil, varnish, etc. One of the best examples used by scientists to illustrate the theory of colour production by interference is the soap-bubble. Every one must have noticed the growth in colour of the soap-bubble as it grows in size, how at first it is almost colourless, and then rapidly changes, in the parts which are fast thinning out, to green and crimson hues, which become more brilliant and are

accompanied with intense blue and orange hues toning into russet, all these colours being in a continual state of seething movement, until finally they merge into colourless greys just before the bubble bursts and dies away. It will be seen that the colours are more brilliant and intense when the film of the bubble is at its thinnest stage of existence, showing that the waves of light interfere with each other more readily when the object that reflects them is exceedingly thin and transparent. There is a limit, however, to this degree of thinness as a colour-producing medium, for just before the bubble bursts the film becomes so thin as to be incapable of showing colours, and at this stage appears a dull grey or black. Some beautiful effects of interference colours may be seen in the bevelled edges of mirrors or other forms of glass, which vary in hue according to the position of the spectator; this variability takes, generally, the orderly sequence of the colours of the spectrum, the reds changing into orange, the latter to yellow, and so on to green, blue and violet hues. Many crystals show interference colours in a similar way.

The beautiful iridescent colouring of antique glass that has been a long time buried is due to interference; the alkali being partially decomposed and removed leaves thin scales or flakes of the silica on which the light acts, and is reflected sometimes through many layers of the silica, producing the most intense blue, crimson, green and orange hues. In the British Museum may be seen a splendid collection of antique glass, exhibiting all varieties of

gorgeous and fascinating colours of the richest and deepest hues, and some have a pearly and delicate range of colouring, whose iridescence is excessively beautiful.

The iridescent colours seen in the plumage of humming-birds, peacocks' feathers, pheasants' plumage, and of many other birds, also the splendid greens, blues, and ruby colours of beetles, moths, butterflies, and other insects, are all due to interference, and the colouring on these birds and insects "change" according to the angle under which they are seen, or according to the position of the spectator, thus illustrating their qualities of "variability," which all interference colours possess, and which distinguishes them from the invariable colours of pigments.

The metallic oxides that cover, or partially cover, the surfaces of copper, silver, and other metal objects, often exhibit variable shades and tints of iridescent colouring; the interior surfaces of many shells furnish indescribable harmonies of colouring, which also belong to the order of interference colours, and the same may be said of the exquisite "Madreperla" tints on much of the old Italian and Hispano-Moresque Majolica pottery.

Some of these wonderful and exquisite combinations of interference colours seen in shells, beetles, butterflies and birds, etc., may furnish the artist and decorator with schemes of colour harmony superior to any that are found in the floral or other domains of nature; the more brilliant combinations might be used with great advantage in stained glass and enamels and pottery, while some of the

more sober and dusky harmonies seen on certain moths' and butterflies' wings could very well be used as motives of colouring for carpets and other textiles, wall-coverings, and other interior decorative colour schemes. Although it must be admitted that successful decorative colour harmony depends on the expression of a correct feeling for colour, and that the eye is the best judge of what constitutes harmony, still even that happy individual known as the "born colourist" is often at a loss to know what particular tint or shade he should select to complete the harmony of some arrangement he is at work upon; when in a situation like this, if he only turns his attention to some of the countless schemes of natural harmonies, it will be an extraordinary thing if he does not find some arrangement similar to his own, and containing the colour or tint required to make up his harmony. On the other hand, the artist may obtain many valuable hints by a closer study of the brilliant and intense arrangements of interference colours, for although many of these combinations are startling, and almost harsh, in their gorgeous effects, they may be rendered into softer and quieter harmonies by slightly darkening or lightening their various hues, and the resultant effects may still be invested with an adequate measure of strength and richness.

CHAPTER II

THE CONSTANTS OF COLOUR—SATURATION

In the course of the preceding chapter we have had occasion to speak of "purity," "luminosity," and "hue" in reference to pigments and colours of natural objects; it will be necessary here to explain what is meant by these terms.

To accurately define any colour, scientists have agreed and proved that it has three principal qualifications, namely its *Purity*, its *Luminosity*, and its *Hue*, and to these three the name of "Constants of Colour" has been given. The first "constant" to be looked for in a colour is its purity, or, in other words, its *freedom from white light*. The pure standard colours are those of the spectrum, and it is by the comparison with its colour in the spectrum that the purity of the colour of any pigment, or natural body is determined. All natural coloured bodies reflect a certain proportion of white light in addition to their coloured light, and consequently suffer a loss of purity in this reflected mixture of white and coloured light. Thus the purity of a colour is lessened in proportion to the amount of white, or white light that has been added to it. It will be seen from

this that no colours, whether of pigments or of natural bodies, can have the purity of spectrum colours. Artists, however, use the term "purity of colour" in a totally different sense, it being generally understood by them that colours are pure when they are free from muddy or dirty tones, for instance, a landscape picture that is painted in a harmony of silver-greys and grey-greens, which may be a correct representation of a beautiful natural effect, and in an artistic sense may be remarkable for its purity of colour, will be, at the same time, an example of impurity of colour from the scientific point of view. Artists often describe colours as being pure, that sometimes reflect, in addition to their coloured light, twice, or more than that quantity, of white light, but in cases of this kind clearness or brightness is confused with purity, for colours, by the addition of white, have their brightness increased and their purity diminished.

This leads us to the second constant of colour, namely, its *Luminosity*, or Brightness. The brightness or luminosity of a colour depends upon the total amount of light that it reflects to the eye. Two red-coloured surfaces, for instance, may each reflect similar proportions of coloured and white light, respectively, but one of them may reflect twice as much total light as the other, the former is therefore the more luminous, and the only way to cause them to agree in point of luminosity or brightness is to expose the one that reflects the least light to a brighter illumination than the other, in order to equalize their tone or shade. It follows from this that the tone of a colour depends on the

degree of its luminosity, and that the latter constant is quite independent of the purity of a colour.

The third constant of a colour is its *Hue.* The spectrum colours have each, as we have seen, different degrees of refrangibility, or different wave-lengths, and according to the degrees of refrangibility or dimension of the wave-length of a ray of decomposed or neutralized light the *hue* of a colour is determined; we name colours, as red, green, yellow, or blue, etc., and by these names we express their hues. The hues of the simple or primary colours, therefore, depend on definite wave-lengths, while those of their complementaries, and of other compound colours, are due to the mingling of wave-lengths of various dimensions and proportions. The hue of a colour is independent of its purity or its luminosity; for instance, colours of widely different hues, such as red, blue, and yellow, may have similar degrees of brightness and of purity.

A colour that is characterized by an intensity of hue is said to be *saturated.*

When the greatest possible degree of purity or richness, combined with a high degree of luminosity, is present in a colour, the effect on the eye is the maximum intensity of hue, or *Saturation.* If, however, a great excess of luminosity or brightness is added to a colour, its intensity of hue, or saturation, is diminished; for example, pale chrome and pale cadmium yellows are more luminous, but less saturated, than the medium, or deep chromes and cadmiums.

Saturation, or intensity of hue, may be studied by

means of the optical instrument known as the "direct vision" spectroscope. This instrument consists of a tube moving within another tube, in which is fixed, close together, a series of five-glass prisms and a lens in front of them, at one end is the eye-piece, and at the opposite is

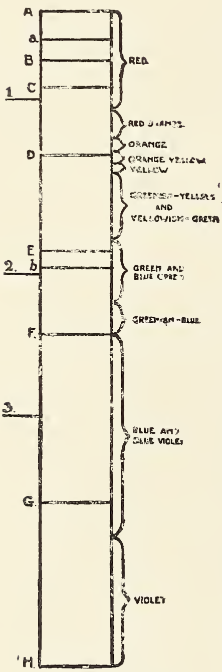


Fig. 2.—Solar Spectrum.

a small perpendicular slit, so that when looking through the instrument the slit is magnified, and opens out into an image of the prismatic spectrum. If the spectroscope is directed to the lower part of the sky, or horizon, it will be found that all the colours of the spectrum, with the exception of red, will appear less bright or luminous than the spectrum obtained when the instrument is directed to a higher and brighter part of the sky; in the latter case the colours seen are more saturated than those obtained from the lower part of the sky, because they are more luminous, although the purity and hue of the horizon spectrum colours remain constant. At the horizon the atmospheric layer is thicker and denser than at the higher parts of the heavens, owing to the presence of suspended water and solid particles, and consequently the sun's light, by passing through this greater density of atmosphere, is weakened before it enters the spectroscope, and the coloured light, with the exception of

the red rays, which are very little affected, is lowered in point of brilliancy.

The relative brightness of the spectrum colours (Fig. 2), according to the researches and experiments of Vierdort and Rood, are shown in the following table of the principal spectral colour regions, dividing sunlight into 1,000 parts—

TABLE SHOWING THE AMOUNTS OF COLOURED LIGHT IN 1,000 PARTS OF WHITE SUNLIGHT.

Red	54	Yellowish-green	121
Orange-red	140	Green and blue-green	134
Orange	80	Cyan-blue (a greenish-blue)	32
Orange-yellow	114	Blue	40
Yellow	54	Ultramarine and blue-violet	20
Greenish-yellow	206	Violet	5
			1,000

Interesting experiments with coloured discs and a rotating apparatus have been made by Professor Rood to determine the relative luminosity of some of the ordinary artists' pigments, which may be described as follows—A small disc of black paper with a white sector was placed on a larger disc of the colour to be tested, and the areas of the white and black sectors were adjusted so that a pure grey was obtained that matched exactly the luminosity of larger coloured discs when both discs were simultaneously and rapidly whirled on the rotating apparatus. Allowance was made for the small quantity of light reflected from the black sector, and putting the reflecting power of white paper at 100, a series of

measurements were made and are here given in the following table—

	LUMINOSITY
White paper	100
Vermilion (in thick paste)	25·7
Pale chrome-yellow (water-colour wash)	80·3
Pale emerald-green (in thick paste)	48·6
Cobalt-blue (water-colour wash)	35·4
Ultramarine (artificial)	7·6

To this list Professor Church has added the results of four experiments of his own, namely—

	LUMINOSITY
Zinc white	110
Whatman's paper (not hot pressed)	97
Natural ultramarine	9·1
Lamp-black	·8

CHAPTER III

THEORIES RELATING TO THE PRIMARY COLOURS—SECONDARY, OR THE COMPLEMENTARY COLOURS TO THE PRIMARIES

It was thought, first by Newton, and long afterwards by his followers, that the seven spectral colours, namely, red, orange, yellow, green, blue, indigo, and violet, were each simple or primary colours, but researches made later proved that there were only three colours which could be properly designated as primaries, and that the other four were produced by various mixtures of the primaries, and consequently were considered as secondaries; even after this was admitted, the question as to what were the primaries was still left open, and some wrong theories on the subject were set up by writers on colour, among them, the great scientist Sir David Brewster, who maintained that the red-yellow-blue theory was correct, but it was propounded by Dr. Young in 1802, that the primary colour sensations were red, green, and violet. Helmholtz followed up Dr. Young's theory by experiments with a more refined apparatus than that used by Brewster, and came to a similar conclusion as Dr. Young regarding the fundamental triad of red, green, and violet. Professor J. Clerk Maxwell

has also clearly proved by experiments with coloured light and by means of his colour discs that the theory adopted by Young and Helmholtz is certainly the only correct one. Yellow exists in the spectrum as a simple colour of definite wave-length, but it may also be produced by a mixture of red and green waves on the retina as a colour sensation.

Although the red-green-and-violet-blue theory of the primary colour sensations is now admitted by all physicists, the position is not quite clear as regards the naming or selection of the exact hues of these colours. More particularly that of the last-named colour. Some have selected a pure blue, some, like Clerk Maxwell,[1] select the blue known as French ultramarine, which is a distinct violet-blue, while Helmholtz selected a decided violet. If a full or decided violet is selected as the third primary, then to make up the fundamental triad we must select an orange-red and a blue-green as the other two colours of primary sensation. It is better, however, to select the three primaries from positions a little nearer the red end of the spectrum, and in doing so the normal red would be represented fairly well by Chinese vermilion, or by scarlet vermilion glazed or washed over with madder-carmine. There is no red pigment that really represents the normal red, but, approximately, the colour known as iodine scarlet, an iodide of mercury, or the Bourgeois "géranium" red, comes nearest

[1] On Fig. 2, page 22, the numbers 1, 2 and 3 mark the positions chosen by Maxwell on the spectrum of the primaries red, green and violet-blue respectively.

the pure red of the spectrum. This colour is, however, fugitive as a pigment. The normal green is best represented by emerald-green mixed with a little lemon-yellow, and the third primary will be a blue with the faintest tinge of violet in its hue, this colour being best represented by genuine ultramarine, obtained from the lapis-lazuli. The latter colour is the purest form of blue known as a pigment, although it has a slight violet tinge, but is entirely free from anything approaching a greenish hue. The three colours just described are widely distant from each other in the spectrum, and when mixed together as coloured lights will produce white light, which cannot be said of the three colours, namely, red, yellow, and blue, that constituted the older primary triad. The new colour theory is now universally adopted by the present-day physicists, and the pigments above mentioned have been selected by Professor Church as those that approximately match the primary sensations of coloured light. An attempt has been made in the diagram, Plate 2, to imitate, approximately, the hues of the primaries, the red at A, the green at D, and the blue, or violet-blue at B. Water-colour washes were used in the preparation of this diagram, and the colours selected were as follows—

Fundamental or Primary Colours.

Red	Vermilion, with a thin wash of madder-carmine.
Green . . .	Emerald-green, and a little lemon-yellow.
Blue	Ultramarine, from lapis-lazuli.

The above three colours fairly represent (in pigments)

the fundamental triad, or primaries. Directly opposite these three colours, on the diagram, will be found approximate representations of their respective *complementaries,* namely, at D, a green-blue or "sea-green," the complementary of the fundamental red, a pale purple, at F, the complementary of green, and yellow, at E, the complementary of ultramarine blue. The *complementary* or contrasting colours of the primaries are compound colours, each being mixtures of two of the primaries, that is, the yellow is a mixture of red and green, as coloured lights (not pigments), the green-blue is a mixture of ultramarine blue and green, and the pale purple (or pink) is a mixture of red and blue. These three complementary colours are also known as *secondary* colours. The three spectral primary colours we have endeavoured to describe, when mixed or superimposed on each other, will destroy or neutralize each other, and will produce white light, and also *any* two tints, or colours that produce by their mixture white or white light, are *complementary colours.* It may be remarked that a mixture of any two or more pairs of complementaries will also produce white light.

The colours used in preparing the complementaries on the diagram were as follows—

Complementaries of the Primaries.

Yellow	Lemon-chrome and aureolin.
Green-blue	Viridian and cobalt and emerald-green.
Pale purple	Ultramarine, rose-madder, and white.

These complementary or secondary colours, with their

The Primaries, Red, Green and Ultramarine-Blue,
with their Complementaries, or Secondaries, Blue-Green, Purple and Yellow.

V. BROOKS, DAY & SON, LTD., LITH.

respective primaries offered on Plate 2, have been tested by the writer with the rotating discs, and each pair produced by rotation a perfectly neutral grey. Similar pairs of complementary colours in the spectrum would, of course, produce white light when mingled together.

In point of saturation, or intensity of hue, the three primaries, red, green, and violet-blue, are the most powerful of the spectrum colours, and their approximate representations in pigments or material colours are also found to excel all other colours in brilliancy and purity, and can rarely be used by artists or decorators except in very small quantities, or when dulled or broken by other colours. Red and violet-blue are colours that are always difficult of management in their pure state, but the fundamental green, which is almost a pure emerald-green, is the most irritating colour of the three; the reason assigned for this is, that it excites the nerve fibrils of the eye much more than any other colour. It is, however, very valuable when used in small quantities, either in a picture or in a decorative composition, for "lighting up" the colour arrangement. The student will soon discover how unmanageable bright and rank greens are when he tries to use them as pigments; the "bright glad green" of Chaucer, and the "soothing" qualities of green to the eye, described as such by many writers, generally refer to the broken greens of grass and foliage which are always mixed with indescribable and lovely tints of warm greys and tender russets.

CHAPTER IV

THE MIXTURE OF COLOURS—EFFECT OF ARTIFICIAL LIGHT ON THE HUE OF COLOURS

By the term *mixed colours* we understand the sensation, or impression of colour, resulting from the simultaneous action of two or more colours on the same portion of the retina. Before we begin our consideration of this subject it will be advantageous to describe some of the methods and apparatus used to produce mixtures of coloured lights. The means employed in the production of mixed colours, when experimenting with the colours of the spectrum, are troublesome and difficult, but, fortunately, there have been several inventions designed by scientific men for investigating the phenomena of mixed colours, two of which are very simple in construction, and can be relied upon to give very satisfactory results. One of these is the apparatus used by Lambert, and others, for the production of mixed colours from any two colours, and known as "Lambert's Method." A representation of this apparatus is given at Fig. 3. Another very convenient method is that employed by Maxwell, which consists of a rotating or whirling apparatus, on which coloured cardboard discs are fastened

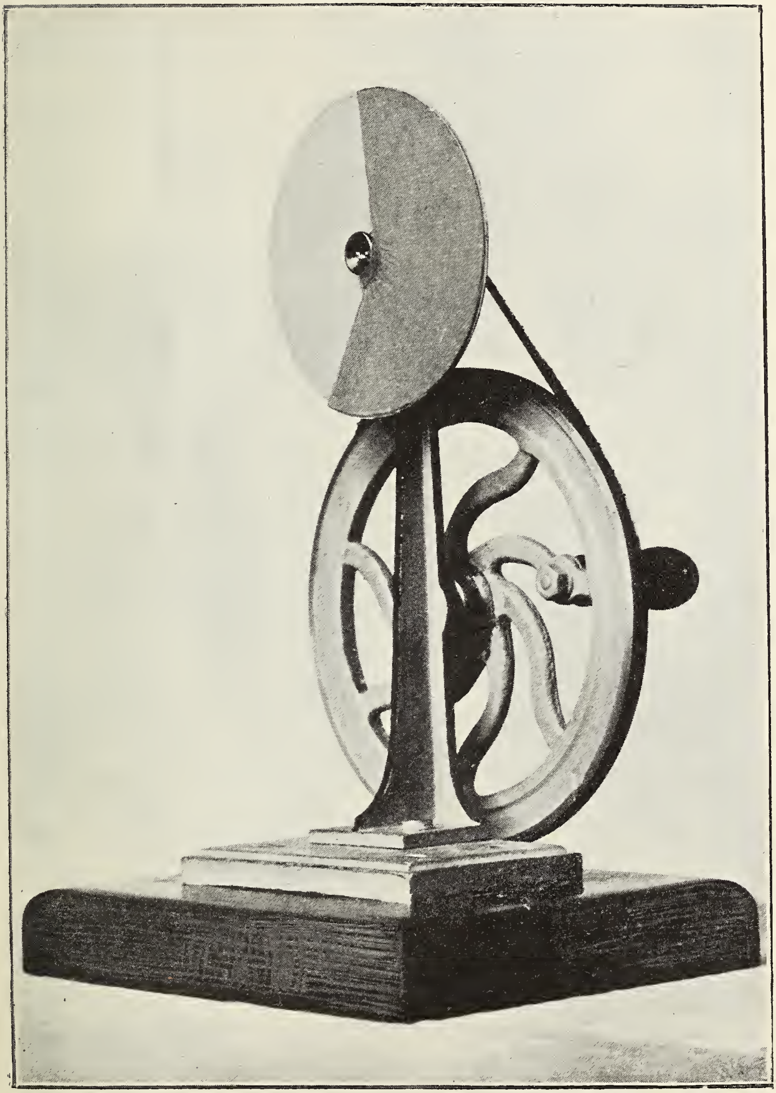


Plate 3.

ROTATING APPARATUS WITH MAXWELL'S DISCS.

on the spindle of the machine, and combined so as to present any desired proportion of the coloured surfaces. An illustration of this rotating apparatus is given on Plate 3.

Lambert's method of producing mixed colours consists in arranging, vertically, a piece of good clear glass, about three or four inches square, ten inches or so above a table, or board, covered with black cloth. (See Fig. 3.) The eye is directed to look through the glass in an oblique direction at a piece of paper coloured, as named in the diagram, blue, while at the same time the yellow light from a piece of paper, painted with a bright yellow, is reflected in the glass, and thence to the eye, where it mingles with the blue light on the retina, and produces the sensation of a whitish-grey colour. The proper positions of the blue and yellow papers will be easily found by trial, when their images will coincide in the glass if the light from the yellow paper covers the blue paper. This production of pale grey, or white of a low luminosity, by the mixture of blue and yellow light goes to prove that the two colours under observation are complementaries, for the whitish mixture would be a pure white light if the same colours were mixed in the spectrum, and we know the result is entirely different when the pigment colours, blue and

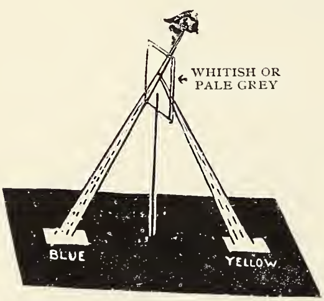


FIG. 3.—Lambert's Method.

yellow, are mixed; the production in the latter is of course a green. Lambert's method is very useful for the purpose of mixing of any two coloured lights and for testing complementary colours; but Maxwell's colour discs enable the investigator to combine two, three, or more colours if necessary. Each disc has a hole in the centre, and a radial slit by means of which one disc, painted with a certain colour, is caused to slide over another, having a different colour, so as to overlap, in order that the area of each may be regulated to any desired proportion. (See Figs. 4, 5 and 6.)

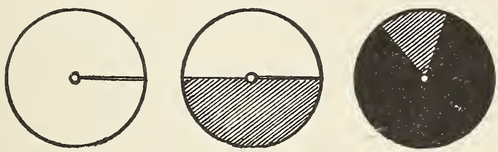


FIG. 4. FIG. 5. FIG. 6.

Maxwell's Colour Discs.

All colours, other than the primaries, may be approximately represented by mixtures of the pigments red, yellow, and blue; the reds mixed with yellows produce a great variety of orange tints, yellow and blue furnish an infinite series of greens, while red and blue mixtures yield a multitude of violets and purples. The varying intensity and purity of such mixtures depend upon the quality, hue, and proportions of the constituent colours of the mixture. For example, if we require a bright purple, the red used must incline to crimson, and the blue to violet, and if a bright

green or powerful orange is desired, we must select the colours to be employed in the mixture from those that approach in some degree to the hue of the colour we are seeking to produce. Thus, there are some brilliant and intense blues, such as ultramarine, when mixed with such a powerful colour as cadmium yellow will only furnish a green of a very dull appearance. The reason for this is obvious, the ultramarine of the mixture is a blue that inclines to violet, and the cadmium is a yellow inclining to orange, or red, hence it follows that these two colours, when mixed, add to the mixture a considerable quantity of red, which united to the green tends to make the latter more greyish or dull. On the other hand, if Prussian blue, which is a greenish-blue, is mixed with gamboge or pale chrome-yellow, the mixture is a much purer and brighter green.

With the three pigmental colours, representing red, yellow, and blue, and the colours produced from their mixtures, and with the addition of black and white to obtain greys and browns, it is possible to imitate the colouring of nature, though not so satisfactorily as when the artist is able to use a wider range of palette.

The knowledge that any mixture of pigments could not produce a pure red, yellow, or blue, led to the adoption in former times of red, yellow, and blue as the three primary colours, and chiefly for the reason that a mixture of yellow and blue gave a green more or less satisfactory, according to the nature of its constituent parts, it was

thought that green light was not a primary colour sensation, but was a mixture of yellow and blue light. This, however, we know, is not the case, as we have seen that any mixture of blue and yellow light will produce white or a greyish-white, but in no case does a mixture of yellow and blue light show any tinge of green.

Yellows and orange-yellows are produced as mixtures of green and red light, for although yellow occupies a very small space in the prismatic spectrum, and has to all appearance the aspect of a simple colour, it can be produced by a mixture of green and red light.

To account for the great difference in some cases, in the mixture of coloured lights when compared with the mixture of pigments, it may be stated, in the mixture of coloured lights one colour is added to the other, but in case of pigments each colour of the mixture absorbs, as a rule, the colour of its companion if they happen to be of opposite or contrasted hues, and the mixture is only able to reflect that particular colour which is not absorbed by either of its constituents. In explanation of this it will be necessary to give an illustration. When a blue and a yellow pigment, for example, are mixed together the mixture may be so thorough that the separate particles of blue and yellow cannot be detected by a microscope, but still the mixture will be a fine mosaic made up of blue and yellow particles, and from the latter a small quantity of blue and yellow light reaches the eye directly, and this mixed light being of a yellowish-grey slightly dulls the green mixture, this

light being greatest in quantity when the mixture is in a powdered or dry state, or when it has a *mat* or dull surface, less when used as in a water-colour, and least in the case of an oil or varnish mixture. But the more important part is effected by the light penetrating a little below the surface of the mixture where the blue particles absorb the red, orange, and yellow rays, and the yellow particles at the same time absorb the blue and violet rays ; the green rays, which are not absorbed by either, remain, and so determine the hue of the mixture. A very small quantity, however, of green light is also absorbed by the blue and yellow particles, but it will be understood from the above explanation how such colours as Prussian blue and gamboge, which are greenish in character, are able to furnish a greater quota of green light and so yield stronger greens, when mixed together, than other blues and yellows of greater brilliancy.

For similar reasons to the above, many bright and pure pigmentary colours when mixed together fail to produce anything in common with their own brilliancy. It may be inferred from this that an artist ought to avoid, as much as possible, the mixing together of pigments, and to use colours as pure and as simple as the nature of his work will permit. If a colour requires to be altered in shade or tint he should for this purpose endeavour to use, when possible, some other colour not far removed from the original colour in point of hue. This appears to have been the practice of Titian and of many other great colourists, especially in the colour treatment of their draperies.

We have seen that when blue and yellow pigments are mingled together, the green mixture is not the result of a perfect union of the two colours, but is a green formed by the residue of green light which is not absorbed from amongst the particles of the blue and yellow pigments, therefore, the conclusion is, that when two pigments are mixed together, the resultant colour is due to a process of absorption which takes place, or *subtraction* of all colours except that which remains as the colour of the mixture. This is in direct opposition to that which happens in the mixture of coloured lights; for in the latter case the resultant colour is brought about by the *addition* of one colour to another.

We have mentioned in another place that yellow is seen in the spectrum, where it occupies a very small space, as a simple or elementary colour, having a definite wave-length, but at the same time it can also be produced by the mixture of the green and red lights of the spectrum. It has therefore been recognized as a compound colour, and is for this reason not included in the list of fundamental colours. In a spectrum of a low illumination, or in the coloured band of the spectroscope, the yellow portion is hardly distinguishable; the green passes into orange at the place where the yellow ought to be. There is no definite yellow space in such spectral bands that reminds us of the yellow hues of such pigments as the chromes, gamboge, or cadmium yellows. We happen to possess a range of luminous and brilliant yellow pigments that far surpasses the

brightness of any other pigments, and although a mixture of green and red obtained by the using of Maxwell's discs, or by Lambert's method, will furnish a yellow, it will appear dull and greyish when compared with the standard yellows furnished by the pigments named above. Green and red light, however, when arranged so as to be seen simultaneously as spectrum colours, will furnish a yellow light, which will change from yellow to orange and red as the intensity of the green light is diminished in the experiment.

The production of yellow or orange-yellow light by the mixture of red, reflected by the rosy dawn of the morning sky on the green waters of the ocean, has been noticed, and beautifully described by Shakespeare in his *Midsummer Night's Dream.* Oberon is conversing with Puck, and exclaims—

> "I with the morning's love have oft made sport;
> And, like a forester, the groves may tread,
> Even till the eastern gate, all *fiery-red*,
> Opening on Neptune with fair blessed beams,
> Turns into *yellow gold* his *salt-green* streams."

Some experiments have been made by the writer in colour mixtures, and the results are given in the prepared diagrams, Figs. 7 and 8.

The diagram, Fig. 7, gives five colours and their mixtures obtained by using the rotating discs; similar results are also obtained by mixing coloured lights obtained from slips of paper painted with the colours named on the top, or left-hand side of the diagram, by Lambert's method.

The colour mixtures will be, in most cases, paler or lighter than those obtained by the rotating discs; this is accounted

	VIOLET	BLUE	GREEN	YELLOW	RED
RED	BRIGHT PURPLE	ROSE	DULL YELLOW	ORANGE	RED.
YELLOW	WARM LILAC	PALE GREY	YELLOWISH GREEN	YELLOW	
GREEN	SLATEY-BLUE	LIGHT BLUE.	GREEN		
BLUE	VIOLET BLUE	BLUE			
VIOLET	VIOLET				

FIG. 7.—Colour mixtures by rotating discs or by Lambert's method.

for by the fact that in Lambert's method one colour is superimposed on the other, and the resulting image has the

	VIOLET	BLUE	GREEN	YELLOW.	RED
RED	DARK PURPLE.	PURPLE.	WARM GREY.	ORANGE.	RED.
YELLOW	GREY-SAGE	GREEN	GREENISH-YELLOW.	YELLOW	
GREEN	DULL OLIVE	SEA GREEN.	GREEN.		
BLUE	DEEP-VIOLET-BLUE	BLUE.			
VIOLET.	VIOLET.				

FIG. 8.—Colour mixtures of pigments.

luminosity or brightness of both colours presented simultaneously to the eye, while in the case of colour mixture by the rotating discs, the images of both colours are presented to the eye in rapid alternation, and the mixture will, there-

fore, only have the mean proportion of the luminosity of both colours.

Some of the colour mixtures in this diagram would present a difference in hue and would gain in purity when mixed as spectrum colours, owing to the absence of white light, which has always to be reckoned on when any other method of mixing coloured lights is practised. The following is a list of a few colours showing the changes which take place when the colours are mixed in the spectrum—

COLOURED LIGHT.		SPECTRUM MIXTURE.	DISC MIXTURE.
Blue and yellow	yield . .	White . .	Pale grey
Yellow and violet	„ . .	Rose . .	Warm lilac.
Violet and green	„ . .	Pale blue . .	Slaty-blue.
Green and red	„ . .	Yellow . .	Dull yellow.

The difference between the colour mixtures derived from the combinations of the painted discs, or that obtained by mixture of coloured lights, and the mixtures of pigments, is very marked, as may be seen on comparing Figs. 7 and 8. When experimenting in order to prepare the diagrams, portions of the same colours were used on the painted discs, as in the mixtures of the pigments, and the results described on the diagrams were arrived at after careful investigation.

The modifications or changes which colour undergoes when it is illuminated by gas-light and other artificial light must now be considered. Any artificial light will alter the hue of most coloured surfaces, as it cannot be so pure as the white daylight, although the improvements which have

been made during the last few years in the development of the white light of the incandescent gas-burners, and in electric lighting, have gone a long way towards the equalizing of the colour of artificial light and daylight, but still the light given by artificial means has the effect of changing the appearance or hue of a colour from its characteristic hue in daylight. Artificial light is deficient in blue rays, and to a lesser extent in violet and bluish-green, and its general tint varies from yellow to orange-yellow, while the tint of daylight is white. Hence it follows that coloured surfaces, when seen under artificial light, will in some cases, as in yellows and orange colours, lose a considerable quantity of their yellow, that is, they will not be so yellow as they would appear when seen in the white light of the day, for in the latter case they appear more yellow by contrast with the white light, so we find that pure yellows like the chromes and gamboge become whitish or pale in artificial light; pure red, on the other hand, becomes brighter and more intense. Carmine and crimson-reds lose their purplish tints and tend toward a purer red, while vermilion inclines to a more orange-red. All orange colours become brighter, and appear of deeper saturation in gaslight, but blues generally suffer in purity, and become dull and greyish. Blues inclining to a violet cast, like French ultramarine, become more violet-like, and all pure blues have a more purplish hue, but greenish-blues like Antwerp and Prussian have a strong tendency to become still greener in hue. Violet is much duller and more purplish,

and purple inclines to a crimson-red. Greenish-yellows and yellow-greens remain fairly constant to their daylight aspect, but turquoise and blue-greens become more bluish, and bluish-greys become almost indistinguishable as colour in gas-light.

An accurate knowledge of the differences in the appearance of coloured surfaces in artificial light, in comparison with their tints when seen in daylight, is of the utmost value to decorators and scene-painters when arranging their colour schemes for churches, assembly-rooms of public buildings, concert-halls, theatres, etc., for it is evident that many tints or shades of colour that make admirable harmonies with other colours in a composition, when seen in daylight, may either appear discordant, or may fade into colourless or dull greys under an artificial light.

CHAPTER V

COMPLEMENTARY COLOURS

A KNOWLEDGE of the composition and appearance of those colours which afford the greatest contrast to each other is of the utmost importance to the artist, and to those who are engaged in artistic trades. Schemes of colour composition that very often appear dull and heavy, or poor and insipid, might be greatly enlivened by some touches of a contrasting, or complementary colour, to brighten and to bring out the full value of the other colours of the composition.

It has been mentioned before, in Chapter III, that if any two colours when mixed as coloured lights will produce white light, these colours are said to be *complementary* to each other.

According to the theory of Dr. Thomas Young, which has been accepted by all physicists, red, green, and violet light, when presented simultaneously to the eye, as in a mixture, will produce the sensation of white. Young and Helmholtz have also propounded the theory, that each minute, or elementary portion of the retina is furnished with three sets of nerve fibrils which are capable of

receiving and transmitting three different colour sensations, namely, red, green, and violet. One set of these nerves is most strongly acted upon by the longest waves of light, which produce the sensation of red, another set is most sensitive to the light waves of medium length, which generate the sensation of green, and a third set of nerves responds strongly to the shortest waves, which produce the colour sensation of violet. Thus the three colour sensations act most strongly on each particular set of nerves that are created for their reception, but the red, green, and violet rays also act in a lesser degree on all the other sets of nerves besides their own. If the three sets of nerve fibrils in the retina are equally stimulated and excited, the sensation of white light is produced, but white light can also be produced when *two* colours excite the three sets of nerves. The explanation of this is, that if, for example, red is presented to the eye simultaneously with blue-green, the complementary of red, the red nerves are stimulated, and the green-blue colour at the same time stimulates both the green and violet nerves, hence the production of white light, due to the simultaneous excitement of the three sets of nerves.

If we take the case of two compound colours which are also complementary to each other, such as orange and turquoise blue, the orange light excites the red nerves in a powerful degree, and the green nerves also, but in a lesser degree (orange being a mixture of red and green with red in the excess); the turquoise blue stimulates both the

green and the violet nerves, and thus by the joint action of the three sets of nerves the sensation of white is produced. In like manner the three sets of nerves are brought into action whenever any pair of complementary colours are presented simultaneously to the eye, as in the case of a mixture of coloured light, just as they also are when the three fundamental colours of light are brought together, for in both cases the mixtures are white light.

Various scientific contrivances have been used for the purposes of obtaining the true complementary to any given colour, but the simplest, and perhaps the best apparatus for giving fairly satisfactory results is the rotating wheel and painted discs. In order to obtain the complementary to any given colour by means of the coloured discs, the hues, tints, or shades of each pair of colours when combined should yield by rotation a perfectly neutral grey, or in other words the colours should neutralize each other; such pairs, when tested as spectrum colours, would produce by their mixture white light.

The great difficulty experienced in finding a true complementary to a pigmental colour is in the wide difference that occurs between the luminosity and saturation, or intensity, of the *warm* colours, such as the various reds, oranges, yellows and greenish-yellows, as compared with the *colder* pigments, such as the pure greens, and the various green-blues, all of which are colours of a much lower intensity. French ultramarine and violet, which are

regarded by artists as cold colours, are, however, quite as intense as any of the so-called warm colours.

To obtain the true complementary to any of the fundamental colours, it is necessary that it should have the combined luminosity of the two colours contained in its mixture, in order that white light may be produced by the union of the three colours, that is, the fundamental colour and the two colours of the complementary mixture. This is the natural condition of the colours of the spectrum, which makes it an easy matter to obtain true complementaries with spectral colours, but in the case of pigmental colours, it is a much more difficult matter to obtain pairs of complementaries that are even approximately correct in hue. Blue-green, which is complementary to the fundamental red, and purple, which is complementary to the fundamental green, must each be mixed with white, or rendered lighter, as in a pale wash of water-colour, on white paper, in order to make them sufficiently bright or luminous to form true complementaries to their respective primary companions, or contrasting colours. (See Plate 2.)

Pure colours of a deep saturation can only be used as complementaries in a limited sense in pictorial or decorative work, for when juxtaposed, or without dividing lines or portions of different colours to separate them, they appear far too harsh and startling, and instead of affording harmonious arrangements, they are more often positive discords. The exception to this is the harmonious association of the complementary pair, blue and yellow.

There are, however, some ways in which we can improve the accordance of any pair of deeply contrasting colours, so as to bring them into a more harmonious relationship, namely, by greatly increasing the illumination of the complementary pairs by adding white or some lighter tones of their own hues that would impart equivalent light to them, or, on the other hand, by decreasing the illumination, or by adding black or its equivalent to each colour, in order to obtain darker shades of each complementary. A third series of complementary colours in *broken* tones may be obtained by a mixture of black and white or *grey* added to any pair of complementaries. (See Plates 4, 5, 6.)

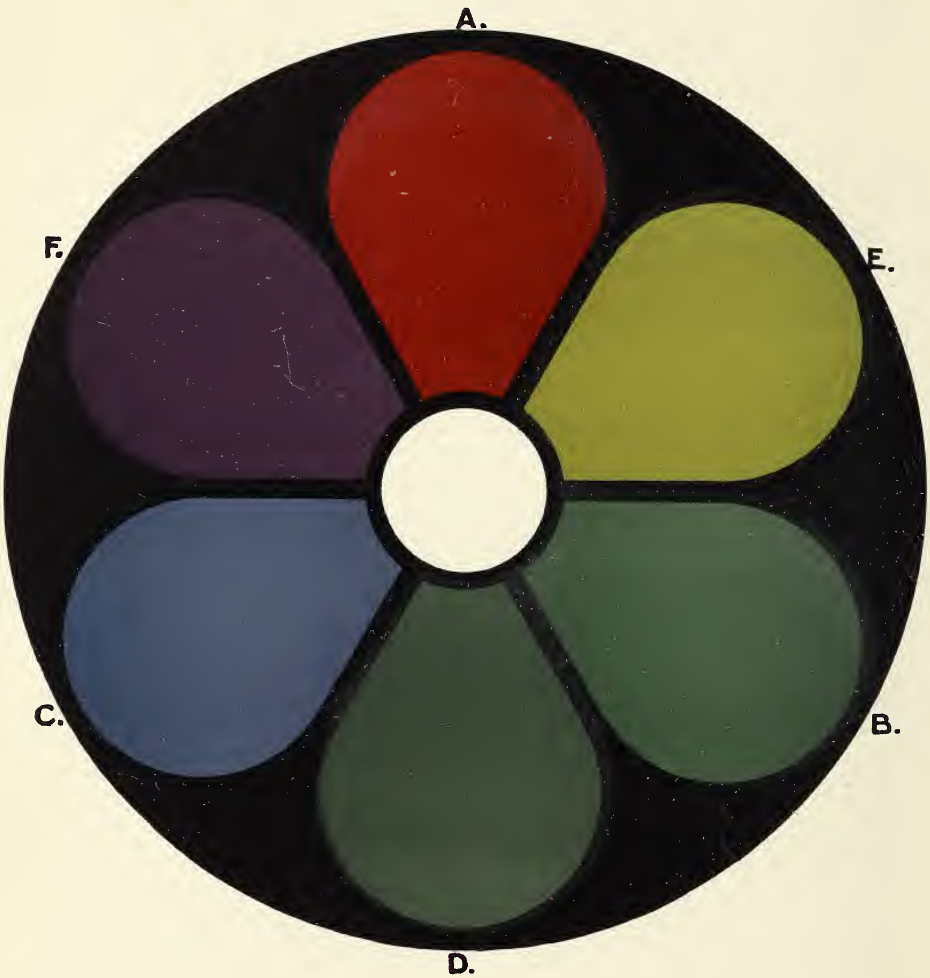
Any colour, in fact, that presents a harsh and unpleasant appearance, due to its excessive brilliancy or intensity, in a colour arrangement, may be brought in accordance with the scheme by lightening it, or, more successfully, by darkening it, thus modifying to some extent, but without absolutely destroying its hue.

When complementary colours are darkened by the addition of black, lightened by the addition of white, or *broken* by the addition of grey, these changes do not prevent each pair so treated from still remaining complementary to each other, the only change effected is that the luminosity of the colours becomes a variable quantity. It will be seen, that by the employment of black, white, and grey with the primaries and their complementaries, we may obtain an almost endless number of complementary pairs. Every colour has also many different comple-

mentaries, for it is only necessary to add black or white to the complementary of a colour, and if the latter, when altered in either of these ways, will still produce a neutral grey with its original complementary, when both are arranged as coloured discs on the rotating apparatus, it will also be a complementary to the original colour, and will only vary in point of luminosity, according to the proportion of white or black it may have in its mixture.

We have prepared three coloured diagrams on Plates 4, 5, 6, which we offer as three pairs of complementaries, on each plate, all of which are modifications in tones, and to some extent into tints and hues, of the primaries and their secondaries, represented on Plate 2. The decorator or designer who uses colour, is well aware that he can very rarely use the more deeply saturated hues in complementary pairs, on account of their violent contrasts, and their inharmonious association, and therefore must modify them in some way to tints or shades of themselves, so as to make them harmonize, and yet preserve a due measure of contrast, which is so indispensable in decorative colouring.

The three pairs of complementaries offered on Plate 4 have been carefully copied from the colours produced by mixtures of those representing the primaries and their complementaries and black. Each primary colour was painted on a disc, and each disc combined with a segment of a black disc, so that a darkened red, a darkened green, or myrtle, and a darkened blue or indigo were obtained on the rotating apparatus; after these colours, obtained by



Darkened Shades of the Primaries and their Complementaries.

V. BROOKS, DAY & SON, LTD., LITH.

rotation, were matched as near as possible by pigments, the respective complementaries, dark green-blue, dark yellow, or olive-yellow, and dark violet-purple were obtained by combining segments of a black disc to each disc that was painted with the secondary yellow, green-blue, and purple, the complementaries of the primary triad; these mixtures thus obtained by the combination of the rotating discs were also copied, and these darkened tones, after various trials, were found to produce, on rotation, when combined with their respective contrasting colours, in each case, a perfectly neutral grey, though varying in luminositv.

The colours in this diagram, and the pigments that were used in its preparation, are as follows—

Darkened Complementaries on Plate 4.

	Pairs of complementaries.	Pigments used in mixture.
A	Dark red, or maroon.	Vermilion, carmine, and black.
D	Dark blue-green	Viridian, cobalt, and black.
E	Olive-yellow, or citrine	Chrome, yellow and black.
C	Dark blue	Ultramarine and black.
B	Dark green, or myrtle	Emerald-green, chrome and black.
F	Dark violet-purple, or plum	Ultramarine, carmine and black.

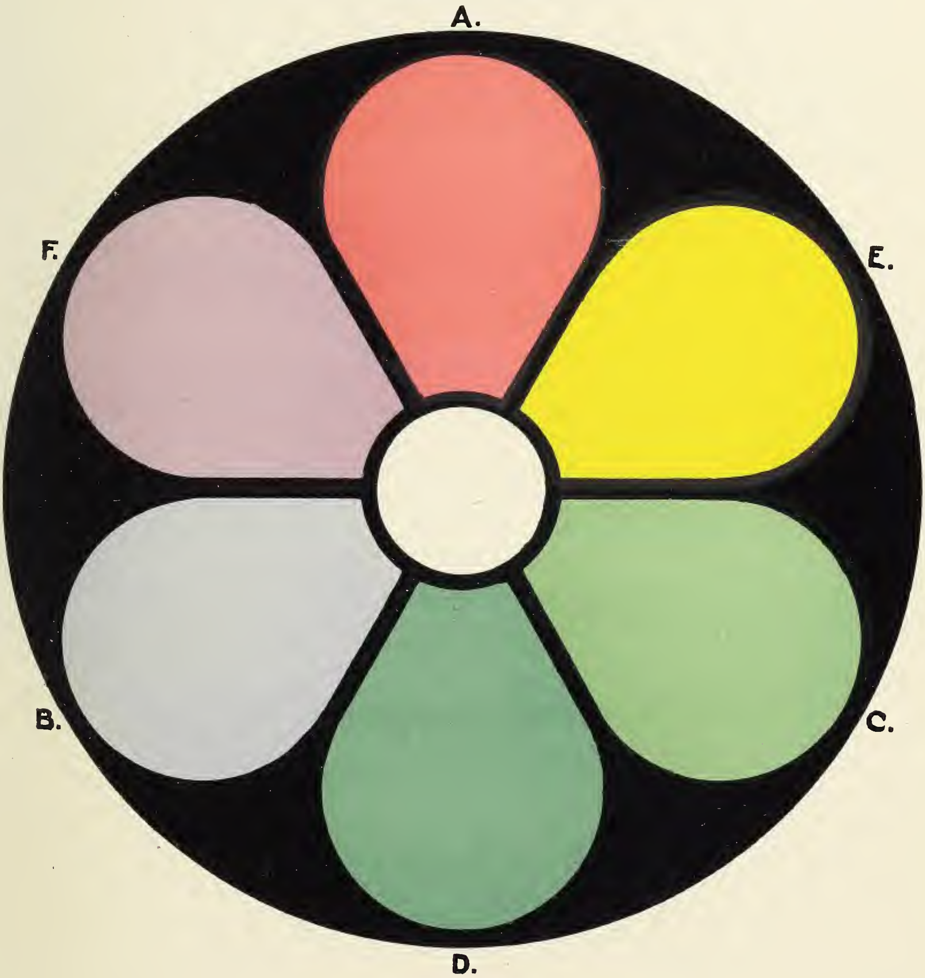
It will be seen from the above table that black has been added to each primary and secondary in the mixtures of the pigments, in order to match the mixtures obtained by the rotating discs, but the quantity used was exceedingly small when compared with the proportion of black that was used in combination with the coloured discs; not more than an eighth, and sometimes much less, of the black was needed in the pigment mixture to match the colour of the

discs. This is a proof of the wide difference in the purity and luminosity which is always found between pigmental mixtures and those of coloured light.

The three pairs of complementaries offered on Plate 5 were obtained by a similar method as that described for the darker pairs, but instead of using a black disc, a white one was combined with the discs of the primary and secondary colours. The colours on this plate present the appearance of the colours on Plate 2, when the latter would be subjected to a high degree of illumination, and therefore offer a very great contrast to the range of darkened complementaries on Plate 4, which represents the same colours when seen under a very low illumination.

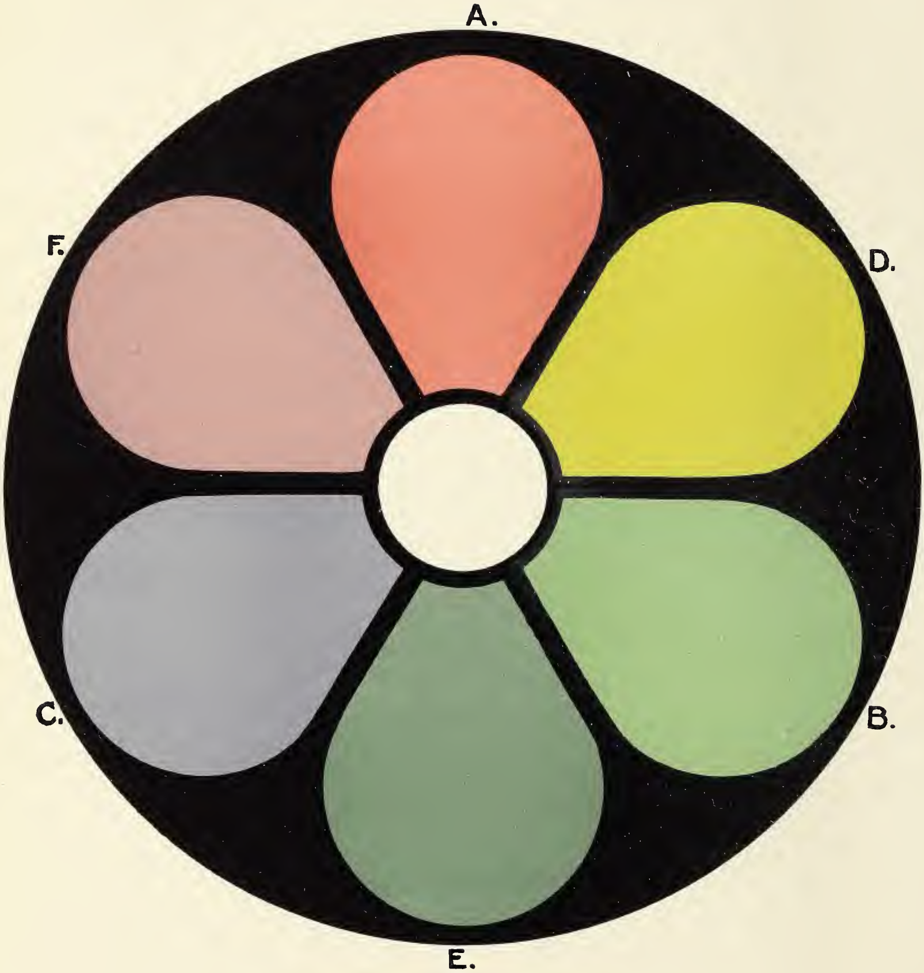
In the matching of the lightened red colour of the red and white disc mixture shown on this plate, of light complementaries, a considerable quantity of yellow had to be used in the mixture with rose-madder and white to obtain the warm rose-pink reflected by the rotating discs; for a white pigment added to any colour, not only lightens the latter but changes the hue, by causing it to incline to a bluish coldness, and this coldness has always to be counteracted, when pigments are used, in painting or decorative art, by the addition of a little yellow or yellow-red colour to the mixture.

The third set of complementary pairs are shown on Plate 6, the colours of which have been obtained by the addition of grey, or a mixture of black and white, to the original complementaries, shown on Plate 2. This set



Highly Illuminated Tints of the Primaries and their Complementaries.

V. BROOKS, DAY & SON, LTD., LITH.



Broken Tones of the Primaries and their Complementaries.

V. BROOKS, DAY & SON, LTD., LITH.

of contrasting colours are perhaps the most satisfactory arrangements, in point of harmonious association of opposite pairs, and they also provide a range of colours that are very useful in decorative art. The modification obtained by the grey in their composition, brings the opposing pairs of broken red with broken blue-green and broken green with broken purple in tolerably good harmony, but the olive-yellow and the dark blue pair of complementaries on Plate 4 afford a better harmony than the broken yellow and blue on the diagram we have been considering.

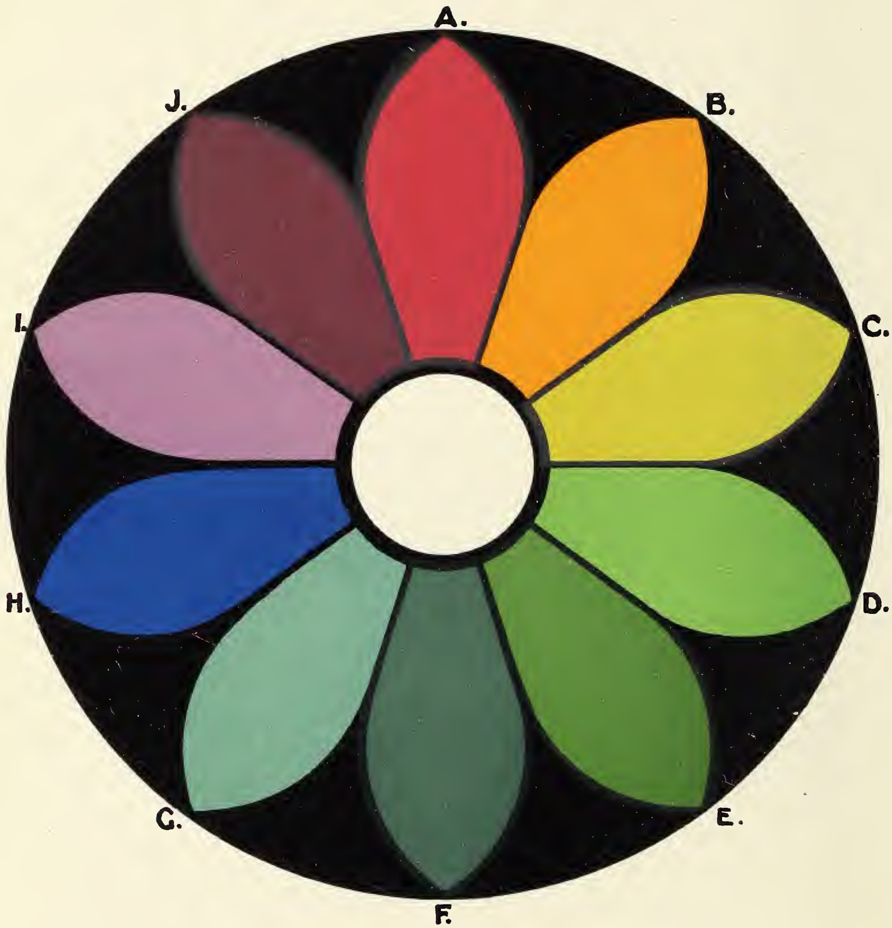
The term "broken" is used to denote a colour of the primaries or secondaries which has been *broken* by the addition of grey, or black and white; the new combinations thus obtained form what are really shades or dulled tones of the primaries and secondaries. The so-called *tertiary* colours, described by many of the earlier writers on colour as different mixtures of the three primaries, or of a primary and a secondary, were nothing more or less than mixtures of two colours, dulled by the addition of grey, for, as we have seen, the mixture of the primaries, or what amounts to the same thing, a pigmental mixture of a primary with its secondary or complementary, produces grey. So there is no new colour or colour sensation that can be properly described as a tertiary. The tertiaries of the older writers were, *citrine*, *olive*, and *russet*, but these are nothing more than mixtures of yellow and grey, green and grey, and orange and grey, respectively, or dulled tones of yellow, green, and orange. The colours therefore

represented on Plates 4 and 6 are all broken tones of the primaries and their complementaries; both sets must be regarded as mixtures of the latter colours in which black and white enter in varying quantities.

The pairs of complementaries represented on Plate 6 as broken colours are—

A	Broken red	or	Greyish-pink.
E	Broken blue-green	,,	Pale bluish-sage.
B	Broken yellow-green	,,	Pale olive.
F	Broken violet	,,	Lavender.
C	Broken blue	,,	Bright slate.
D	Broken yellow	,,	Pale citrine.

We give on Plate 7 a further selection of complementary pairs of colours, all of which have been obtained by the use of the rotating discs. In this diagram, five pairs are arranged in a circle, each colour having its complementary opposite to itself. An orange-yellow and a purple have been introduced in this diagram, with their complementaries, turquoise and yellowish-green; French or artificial ultramarine has for its complementary a greenish-yellow, orange-red has green-blue, and pale violet has yellow-green. The tones of the colours here submitted have been selected with a considerable amount of care and trouble, and though they cannot be absolutely perfect, owing to the difficulty in obtaining amongst pigment colours anything like the exact hues that will when mixed, or when used pure, match, even approximately, the hues of coloured light, still it is to be hoped that they will be found useful to students, and to those engaged in practical colour decoration.



Five pairs of Complementary Colours forming a Chromatic Circle.
Each Colour has its Complementary directly opposite.

V. BROOKS, DAY & SON, LTD., LITH.

In the preparation of this diagram (Plate 7) the pigments used as water-colours are named below—

Pairs of Complementaries.		Water-colours Used.
A	Orange-red	Vermilion, and chrome-yellow.
F	Green-blue	Viridian, cobalt, and emerald-green.
B	Orange-yellow	Cadmium-yellow, and orange-cadmium.
G	Turquoise	Cobalt, emerald-green, and Antwerp blue.
C	Greenish-yellow	Lemon-yellow, aureolin, and emerald-green.
H	Violet-blue	French, or artificial ultramarine.
D	Yellow-green	Pale chrome-yellow, and emerald-green.
I	Violet	Ultramarine, and rose-madder.
E	Yellowish-green	Chrome-yellow, and emerald-green.
J	Purple	Rose-madder, and ultramarine.

In the above table, the water-colours named first, in the case of each mixture, were used in the greatest proportion, the second in less, and the third, when used, in the least proportion.

CHAPTER VI

CONTRAST OF COLOURS

In the previous chapter we have considered the contrasts of opposite or complementary colours, and the modifications due to a higher and a lower degree of illumination on these colours, but there are some other and very important ways in which colours can be made to contrast, not only with each other, but with themselves, that is, they can be changed, or considerably modified in appearance, by simply placing them contiguous to each other or by surrounding one colour by another.

Contrast of colour is due to the modifications in the appearance of colours that are caused by the differences in hue, brightness, and purity of adjacent or contiguous colours.

If any two colours, differing in hue, are placed together, their difference will be increased, and each of the colours will be slightly tinged, as if mixed with the complementary of the other.

This law of contrast is best illustrated when two complementary colours, equal in brightness, are placed close together, then each complementary enhances the purity and brightness of its companion colour to the greatest

possible extent. In the case of colours that are not complementaries, or of colours which differ in degrees of purity, hue, or brightness, the difference or dissimilarity is augmented when the pair are brought close to each other, or in other words, the colour which has the greatest degree of purity, intensity of hue, or brightness, has all these qualities enhanced by coming in contact with a colour which may have lesser degrees of similar qualities, and the latter colour will have its dulness increased by contrast with the brighter and purer colour. The contrast effected by these modifications of hue, brightness, and purity, which occurs when any two different tints or shades of colours, placed side by side, are viewed together, has been called *simultaneous contrast of colours.*

One of the chromatic contrasts of colour is caused, as we have seen, by the difference in the brightness, or luminosity of colours ; this is called their *contrast of tone.* When a deep or dark colour, for example, is placed beside another lighter, but different one, the dark colour becomes still darker and the lighter one increases in brightness ; this is independent of the effect produced by each colour being tinged, as if it were mixed, with the complementary of the other. We shall return to the examination of the causes and effects of chromatic contrast, but at present it will be necessary to give some illustrations in explanation of the contrast of tone, or light and shade, that is, where the effects of contrast are due to combinations of black, white, and intermediate shades of grey.

Chevreul's illustrations of the contrast of *tone* are very instructive, and are given at Figs. 9 and 10. The first (Fig. 9) consists of four slips of paper, two placed

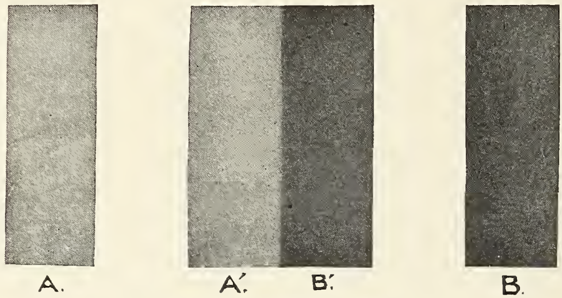


FIG. 9.—Contrast of tone.

together and two separate, which are painted in two shades of grey. A and A′ are identical in their shade of grey; B and B′ are also identical, but have a darker tone of

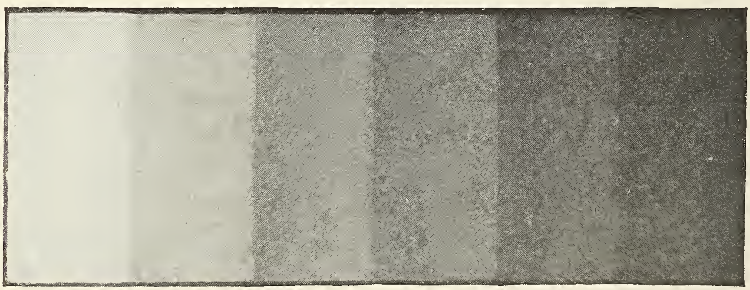


FIG. 10.—Contrast of tone.

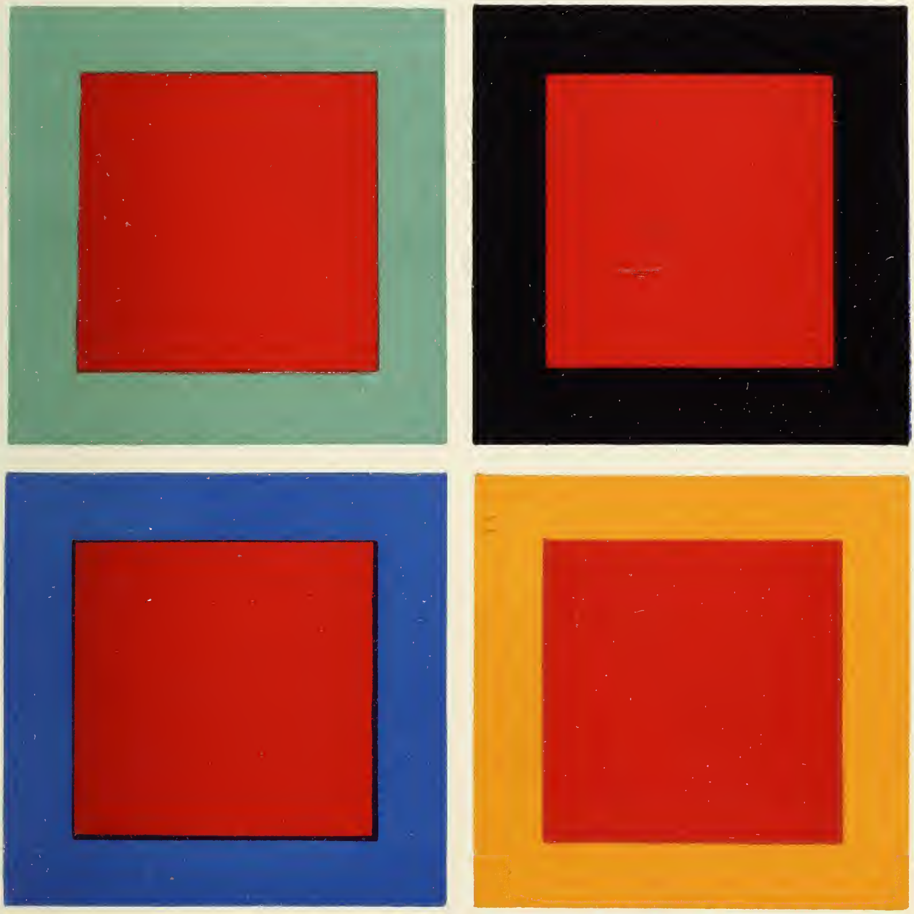
grey. It will be seen that where A′ joins B′, along and near the line of junction, it appears lighter than the tone of A, and this light tone gradually appears to deepen, or gets somewhat darker, as it approaches the outer upright edge.

The contrary effect is noticed in B′, that is, it appears darkest where it joins A′, and grows slightly lighter towards its opposite edge. If the diagram is looked at steadily for a little time, it will be seen that A appears to be darker than A′, and B lighter than B′, though we know that the lighter pair of slips are exactly of the same tone, and the darker pair are also similar in tone.

The other diagram, Fig. 10, still further and better illustrates this phenomenon of tone contrast. A band is divided into six equal parts, and each painted in single tones varying from a light to a dark grey; each upright division is of a perfectly flat and uniform shade, but the effect of the whole together is that of a shaded portion of a channelled or fluted column. Each division, with the exception of the two end portions, appears as if hollowed out; this delusion is caused by the contrast of tone, and is effected by the edge of a lighter one in contact with that of its darker neighbour. Precisely the same thing would happen if the tones of any colour were used in the same way, instead of grey, but a difficulty arises when chromatic colours are used in gradated tones, owing to the impossibility of obtaining a perfect gradation in tone of any one colour, for when white or black is added to a colour, it does not, as we have seen before, merely lighten or darken its tone, but also alters considerably its purity and hue. For practical purposes, however, in decorative work, two or three fairly true gradations of any given colour may be obtained by careful mixtures with pigments a little lighter

or darker than itself; when broken colours are used gradated tones are much more easily obtained.

We shall now consider some of the changes in the appearance of colours due to simultaneous contrast. A colour is changed, or modified considerably, when it is placed in juxtaposition, or is surrounded by another of a different hue or tone. An example of this law is illustrated on Plate 8. On this coloured diagram the vermilion-red square on the orange ground appears darker than any of the other red squares; the square on the blue ground appears somewhat orange in hue; the square on the black ground is the clearest and brightest of the four, and that on the blue-green ground appears to be of the purest red, or is redder than any of the other three, that is, it is the most deeply saturated. Each square, however, is identical in colour, the hue, purity, and brightness being altered in each, except in the case of the square on the blue-green ground, by the influence of the surrounding colours. The square on the orange ground appears darker than the others, and inclines slightly to purple; first, because the orange ground, being lighter in tone, darkens the tone of the red by contrast, and second, the hue and purity is altered because the orange-coloured ground imparts to it a slight tinge of green-blue, or turquoise, the complementary of orange; the effect is just the opposite to this in the case of the red on the blue ground, the red square is here more luminous, or yellower, because it is tinged with yellow, the complementary of blue. The red square on the black



Modification of Tone and Hue of a Colour when placed on or near Different Colours.

V. BROOKS, DAY & SON, LTD., LITH.

ground is greatly increased in brightness, or luminosity, and so looks lighter, by its contrast with black, than any of the other three; this increase of brightness gives it an orange hue. The red square on the blue-green remains unaltered, or constant to the hue, purity, and brightness of the vermilion-red used in the preparation of the diagram, because it is placed on a blue-green ground, the complementary colour of red, and any modification it might undergo would only tend to improve its intensity of hue. If the red squares were much smaller in size, the coloured grounds would also appear modified in tone and hue, by having a tinge of blue-green, the complementary of red, but owing to the small area of the coloured grounds in the diagram, this modification, though present, is not clearly recognized in each case.

From the above illustrations it will not be difficult to understand how any colour, when placed on or adjacent to another, will be changed in appearance in at least two ways. First, by receiving a tinge of the complementary of the contiguous colour—its chromatic contrast; second, by the contrast of light and darkness, or contrast of tone. The red square on the black ground, for example, appears lighter than any of the others, and the orange ground being the lightest of the four grounds, causes the red on it to appear at its darkest; further, if the red square were placed on a still lighter ground or on white, it would then appear darker still than any of the reds in the diagram. Any other colour used in a similar experiment would give

analogous results, and the student is strongly recommended to carry out similar experiments, using a wider range of colours in contiguous pairs.

Colours may also be contrasted with squares or discs of grey, say of a medium grey tone, when it will be found that if the discs are placed in the centre of a square of any bright colour, they will be tinged, as if mixed with the complementary colour of the ground; thus the grey disc on a red ground will be tinged with a pale bluish-green tint, that on a yellow ground with blue, on a blue, with yellow, on a purple, with green, and on a green ground with purple, etc. This phenomenon of simultaneous contrast may be further, and even better illustrated by placing a very thin piece of white tissue-paper or pale and transparent tracing-paper closely over coloured grounds on which the small grey squares or discs are also placed, when it will be seen that the grey is intensified more deeply, or diffused with a stronger tint of the complementary colour of the ground. Although with any bright colours the grey in the above experiment alters in the direction described, yet the best results are obtained when the colder colours are used, that is, the greens, blues, and violets, etc. Thus pale tints, or those that have a considerable quantity of white, or white light, added to them, which is accomplished by the use of the white tissue-paper, or tracing-paper, in the above experiment, produce with greys much greater contrasts than those obtained by more strongly saturated colours; from this we learn that a pale tint of any colour

when placed beside a neutral grey, in painting or decoration, will alter the latter to a far greater extent than would be the case when the grey is in contact with, or close to, a colour of much greater intensity; but on the other hand, if the more positive white, or the negative black, be thus contrasted with any pale colour, the white is very little altered, and the black will only be very slightly tinged with the complementary of the pale tint, just sufficient to degrade its purity.

Pale colours when seen simultaneously and adjacent to each other, offer a much stronger contrast than those of a deeper saturation, and those that are of dark hues, especially if the lighter colours have each about the same degree of luminosity; this may be accounted for by the fact that colours of a pale or bright tint, if fairly pure, resemble deeper saturated colours that are illuminated by a very brilliant light, and the eye is extremely sensitive to colours so "lighted up," and so we perceive the contrast of pale colours at the slightest glance; the great amount of reflected light sent from pale colours to the eye clears the vision, and augments our power of seeing, performing a similar action to that of spectacles or magnifying glasses on the eyes of people whose sight is impaired. Because of this strong contrast offered by pale colours, it is a more difficult matter to harmonize them in decorative schemes of colours than dark contrasting colours, or than broken colours, that is, those that are mixed with grey.

A deeply saturated colour and a paler tint of itself,

when placed together, are both altered considerably, the tendency of the former is toward a still more intense saturation, and the latter to appear still paler, that is, when a strong colour is placed beside a weaker colour of its own hue, the stronger gains more power and brilliancy, and the weaker appears still feebler by contrast. A deep ultramarine-blue, for instance, if contrasted side by side with a pale tint of itself, will cause the latter to appear like a pale ashy-grey, or almost colourless, but its own depth and brilliancy will be increased; the ashy-grey tint of the weaker colour would, on the other hand, give place to a fairly bright blue, if it were placed beside a yellow colour. A pale red tint when placed beside a dark or full red will appear much paler, and often a very pale red against a deep red will pass almost into white by contrast, but if the latter is placed on a white ground it gains very much in saturation. Dark dull colours appear still duller when placed on a white ground, but with black they gain in brightness and saturation. What would be a red-brown or a purple-brown on a white ground would be almost red if placed on black; in the case of Indian red, for example, it is a dull purple-brown when placed on white, but a fairly bright red when surrounded by black.

All colours on a white ground appear at their darkest, while on a black ground they are seen at their lightest. On a grey ground their contrast depends on the strength of the grey, and although a colour will not appear so bright on a grey ground as it would when placed on a ground

of its complementary colour, still the normal hue of the colour would be better maintained than when it is seen on a black ground. The tone of the grey ground has also a modifying influence on the luminosity of colours that are placed on or adjacent to it; it need hardly be said that if the grey ground is darkened the contrasting colour will be proportionately brightened.

Coloured slips of paper, representing the colours named below, were placed on grounds of white, light and dark grey, and black respectively, and the following effects and modifications were observed—

1. RED.—*Red* on a *white* ground appeared darker, purer, and more intense.

2. *Red* on *pale grey* became brighter but less intense.

3. *Red* on *dark grey* brighter still, but loses in saturation.

4. *Red* on *black*, very bright and luminous, as if yellow were added to it; the combination of red with all the above grounds is very good.

5. YELLOW.—*Yellow* on a *white* ground, slightly dull, having a tinge of greenish-brown, is deep in tone, but loses much in brightness; the combination is good.

6. *Yellow* on *light grey* is improved in brightness, the cold tone of the grey gives the yellow a warmer appearance.

7. *Yellow* on *dark grey* is brighter still, and the combination of the above two is excellent.

8. *Yellow* on *black* becomes very brilliant and rich, but paler, and offers a stronger contrast than any colour with black; this is partly accounted for by the black becoming deeper in hue, by having a tinge of blue, the complementary of yellow, added to it; the combination is very pleasing.

9. GREEN.—*Green* on *white* is more saturated and deepened in tone; it accords well with white.

10. *Green* on *light grey* tends to become slightly yellowish, but is of a deep tone.

11. *Green* on *dark grey* becomes brighter, but the grey appears slightly reddish.

12. *Green* on *black* is much paler, but brighter; the black is degraded, as it acquires, by contrast with green, a rusty appearance.

13. BLUE.—*Blue* on *white* becomes dark and rich, if anything it inclines more to violet than to green; the combination is good.

14. *Blue* on *light grey* is slightly more luminous, but the grey, by contrast, has a dull, yellowish tint; the combination is fairly good.

15. *Blue* on *dark grey* is brighter, but the grey is more of a rusty hue.

16. *Blue* on *black* is more luminous, but the black, by contrast, is inclined to olive; light blues on black appear very much lighter, and dull blues appear more intense in hue; the combination is not good.

17. BLUE-GREEN.—*Blue-green* on *white* is darker and greener in hue, it accords well with white.

18. *Blue-green* on *light grey* is slightly dull in hue; the combination is not so good as on white, especially when both are nearly equal in strength of tone.

19. *Blue-green* on *dark grey* becomes more bluish and brighter, and the combination is improved.

20. *Blue-green* on *black* is very luminous and inclines to blue; the combination is cold.

21. ORANGE.—*Orange* on a *white* ground becomes darker and redder; in the case of pale orange and white, the former appears more intense in hue and the combination is good.

22. *Orange* on *light grey* appears more yellow and consequently lighter.

23. *Orange* on *dark grey* becomes still yellower and brighter, and is a good combination.

24. *Orange* on *black* becomes very luminous and in combination is very harmonious.

25. VIOLET.—*Violet* on a *white* ground becomes very deep by contrast; medium and light tints of violet give fairly good combinations with white.

26. *Violet* on *light grey* becomes lighter and is more purplish; the combination is pleasant.

27. *Violet* on *dark grey* is lighter still, and inclines still more to purple.

28. *Violet* on *black* does not give much contrast, the tones of both are more equalized, but the violet inclines to purple.

29. PURPLE.—*Purple* on *white* becomes darker and inclines strongly to violet; light tints of purple afford good combinations with white.

30. *Purple* on *light grey* becomes brighter; the combination is good, the grey tends to sage-green.

31. *Purple* on *dark grey*, the grey becomes slightly greenish; the combination is fairly good.

32. *Purple* on *black*, the black loses its intensity; the combination is not good when the colours are used alone, but if in the case of purple and black, and also violet and black, small quantities of pure yellow or orange were introduced, the arrangements would be excellent.

It will be seen from the above description of the modifications of colours in contrast with white, grey and black, that white heightens the tone of all colours by destroying, by contrast, the greater portion of the white light that is reflected by each colour, that a near proximity to greys lessens the saturation of most colours, but slightly increases their brightness, and finally, that black in association with colours permits them to reflect a greater amount of white light, which gives them a more brilliant appearance, but lessens their intensity of hue. In connection with the relation of colours with black, we might mention that in the case of black patterns in a design on coloured grounds, the black improves, as a rule, the colours of the ground in the direction of greater brightness, but the black patterns, particularly if they are fine, or small in surface area, will be considerably changed in hue, in some cases being inclined to rusty, greenish, or yellowish hues, and in order to counteract this tendency, the black or dark grey pattern colours will require to be mixed with a little of the colour of the ground on which they are placed.

We shall now consider another kind of colour contrast which is known as the *successive contrast of colours*. This

kind of contrast is called *successive* because we look in succession from one colour to another.

If a small square or disc of any brightly-coloured paper is placed on a ground of grey or black, and steadily gazed at for a minute or so, and then suddenly jerked away by a thread that has been fastened to it, or by any other means, the portion of the ground colour, which had previously been covered by the brightly-coloured piece of paper, will appear to the eye in the luminous image of the coloured paper, but having a pale tint of the complementary colour of the small square or disc, as if the spectre of the latter presented itself in its complementary coloured light. A red paper would present a blue-green spectre of itself, a blue paper, a yellow after-image, and a violet, a yellow-green spectre, etc. These spectres are called the *negative* or *reversed* images of the coloured papers, and are always complementary to them.

The phenomenon of successive contrast is explained by the theory of Young and Helmholtz; that, when looking at a coloured slip of paper, say a bright red, the red nerve fibrils of the retina are highly excited, and, on the contrary, the green and violet nerves are not, to any great extent, called into action, and when the red paper is suddenly removed the green and violet nerves, not being fatigued, respond very strongly to the stimulus given to them by the absence of the red paper and presence of grey light, and consequently, the eye for a short time receives the impression, or sensation, of green-blue, the complementary

of red, which is a mixture of green and violet light, and is caused by the unusual activity of the green and violet nerves.

Instead of a grey or black ground, if we employ any coloured ground, bright blue, for example, and place on this a small square or disc of a different colour, such as emerald-green, after looking steadily at the green paper for a little time, and then taking it quickly away, we shall see a bright violet spot of colour in its place, or indeed, if after looking for some time at the green spot we direct the eye to another part of the blue paper, we shall also see its image in violet, but not quite so clear, nor of so long duration, as in the former case. The violet colour of this after-image is of course due to the complementary red of the green colour in mixture with the blue of the ground. If this arrangement of coloured papers is reversed, so that a small blue slip of paper is placed on an emerald-green ground, the after-image is a brilliant greenish-yellow caused by the complementary yellow, of the blue, in mixture with the green; the latter colour by contrast with the greenish-yellow image will appear a dull grey-green. A green spot on yellow paper, in a similar way, will give an after-image of orange, and a blue on red will give an orange-red image.

If we take the case of colours that are complementary to each other, and make similar experiments in this direction, we shall obtain some extraordinary results. If a small square of blue paper is placed on a ground prepared with

the most brilliant tint of yellow that is possible to get with pigments, such as chrome-yellow, and after gazing steadily for a little time at the blue square, on its sudden removal we shall see a very brilliant and intensely saturated image of yellow, that will so far exceed the brilliancy and saturation of the yellow ground, as to make the colour of the latter look dirty and greyish in comparison. Green on a red ground in the same way will give an after-image of intense red almost approaching the spectral red, and a similar action takes place in the case of the other complementary colours, when used as in the above experiment.

If instead of employing the complementary we used a small disc or square of black paper on a coloured ground, the results would be similar, but the after-images would not be quite so bright or intense in hue as when complementary colours are employed.

We have spoken of the dull and greyish appearance of the bright-coloured grounds when compared with the highly luminous and saturated hues of the after-images, and this dull aspect is all the more extraordinary in the case of brilliant grounds, like yellow, for instance, but an examination of the phenomenon will prove that the dull appearance did not, in any great measure, belong to the natural tone and hue of the colour in question, but had really developed by degrees on the surface of the colour, and was caused by the fatigue of the green and red nerves of the eye (which enable us to receive the sensation of yellow) from gazing an unnatural length of time on the colour; the nerves thus

fatigued become unable to respond to the proper hue of the colour presented to them, and the latter appears duller, as if mixed with grey; but the blue spot having protected a portion of the nerves which respond to yellow, on its withdrawal the after-image appears doubly increased in brilliancy and hue.

We learn from this how much the eye becomes fatigued after viewing very bright colours of the same or of similar hues for a length of time. If we are shown a series of reds in fabrics, and if they are of similar shades, or even of the same shade of red, the last specimens shown will appear to have a dull or dingy hue, compared with what we remember as the colour of the first sample. This is because the red nerves of the retina become gradually fatigued by looking too long at one colour, and require either a period of rest, or that a series of other colours, or complementaries of the first colour should be looked at, so as to refresh the eye if it is intended that we should see the last samples of colour in the fabric in their full degrees of brightness and intensity of colour.

In painting, and in decorative colouring, successive contrast exercises a subtle but effective influence on the modification of colours, especially on those that are contiguous to each other, as in cases of simultaneous contrasts, and the production of the effects, due to the latter variety of contrast, involves the action of successive contrast, for the *negative* image is always present, and, in some degree, modifies the colours under observation. In copying the

colours of draperies, in painting, the colours of still-life subjects, or any natural effects, or even in copying pictures, there is presented to us many complicated problems and material for the illustration of successive and simultaneous contrasts. The student, when copying the colour of some brightly-coloured object that may happen to be in a still-life composition, will perhaps obtain a true representation of the colour he sees in the object when looking at it intently, and apart from some other differently-coloured objects in the group, but more than often he will find that this colour he has been at so much pains to get right is altogether different in tone or hue when he places another colour of a different object near to it, or even a little removed, that is, he may forget, until he is forced to see it, that one colour will considerably modify the tone and hue of another in proximity to it. It is also a very common thing to see mistakes of a similar nature made by people who copy pictures. If one goes through a national picture gallery on "copying" days, there will be seen many copies of pictures in process of execution, but a very small percentage of them appear to have anything like the colour of the originals. This often comes of staring for a long time at, say a blue or a red colour, as the case may be, and then trying to match it, and so on with all the colours seen in the original work, but the colours when looked at intently in this way have not the true tones that the artist used when painting the original picture, for the true colour tones can only be seen by looking at *all* the colours together, the

tones and hues being all changed or modified by the simultaneous action of one colour with another. The picture copyist generally finds, in spite of well-meaning attempts to look at the colour in a picture as a whole, that when working he keeps his eye on individual colours to the exclusion of others, and this amounts to almost the same as if he had taken a piece of grey paper, and after cutting out the shape of the particular surface occupied by the colour he is copying, he had isolated this colour by placing the paper on the original picture. It is needless to say that the colour would appear utterly different when so isolated, and something approaching the result that this gives takes place in picture-copying, if the precaution is not exercised of continually looking at the colours as a whole.

The following list given below may be useful in showing some of the principal changes due to the contrast of colours that are arranged in pairs—

Colours in Pairs.	Modification due to Contrast.
Red	appears more purplish.
Orange	,, ,, yellowish.
Red	,, ,, purplish.
Yellow	,, ,, brilliant.
Red	becomes more intense.
Blue-green	,, ,, intense.
Red	appears more orange-red.
Blue	,, ,, greenish.
Red	,, ,, orange.
Violet	,, ,, bluish.
Orange	,, ,, red-orange.
Yellow	,, ,, greenish.

Colours in Pairs.	Modification due to Contrast.
Orange	appears more red-orange.
Green	,, ,, bluish-green.
Orange	becomes more intense.
Green-blue	,, ,, intense.
Orange	,, ,, brilliant.
Violet	appears more bluish.
Yellow	,, ,, orange-yellow.
Green	,, ,, bluish-green.
Yellow	,, ,, orange-yellow.
Green-blue	,, ,, blue.
Yellow	becomes more brilliant.
Ultramarine blue	,, ,, brilliant.
Green	appears more yellowish-green.
Blue	,, ,, purplish-violet.
Green	,, ,, yellowish-green.
Violet	,, ,, purplish-violet.
Greenish-yellow	becomes more brilliant.
Violet	,, ,, brilliant.
Blue	appears more greenish.
Violet	,, ,, purplish.
Violet	,, ,, bluish.
Purple	,, ,, crimson.

CHAPTER VII

HARMONY OF COLOURS—THE SMALL INTERVAL AND GRADATION OF COLOUR

We have seen in the preceding chapter how the harmony of complementary, or deeply contrasting colours, may be helped by the modification of one, or of both complementaries, towards light, or darkness, or by the mixing of the more brilliant tints with grey, but, apart from this, there are other ways of obtaining colour harmonies. One very important method of obtaining colour harmony is by the gradation of each colour in lighter or darker shades; another is, by the mixture of colours with others of closely related hues, where one colour may pass by very gradual, but marked intervals into another; and a third way of securing harmony is to have one colour in the scheme predominant, either by its surface area, or intensity, or by having most of the other colours in the arrangement leaning to, or toned with, the hue of the dominant colour; this might be called the "Harmony of a dominant hue," and would have an effect, that would be somewhat similar to that of any colour arrangement, or a landscape, when seen through a piece of coloured glass.

Brilliant and intense colours are always very difficult to harmonize in pairs, but if it were necessary to have a pair of brilliant colours in any particular scheme of decoration, care must be taken to use one or other of the pair in a much greater proportion, either of area, or of intensity, than its companion; for instance, if orange-yellow and blue, which are perfectly harmonious together, are used in the same proportion in a scheme of colour, the effect will be unsatisfactory and bewildering, as each colour will appear to fight for the mastery, one or other colour must be distinctly dominant in order to give that sense of proportion and artistic balance which is looked for in true colour harmonies. The same is also true in regard to other arrangements where three or more colours are used, the æsthetic or artistic balance must always be preserved, and this can only be achieved when one of the colours is dominant, and the other colours of the composition used in varying quantities of area, or intensity, but no two colours in any scheme, however complex, should, as a rule, be used in similar quantities. This is a law of colouring based on nature, and is analogous to the æsthetic laws which govern the construction of good architecture and ornamental design.

The "balance of colours" and the "neutral bloom" of colour arrangements advocated by some writers on colour, and by some designers, have been based on the laws of optical balances, that is to say, that when the colours were used in the proportions laid down they would neutralize each other, and it was argued from this, that such arrange-

ments must be æsthetically harmonious, but even if they did neutralize each other, it was a condition of things distinctly opposite to the harmonious colouring of nature, or to that seen in the works of our greatest colourists, where the expression of good colour is the thing sought for, and not the neutralization of colour. One gets weary of a "neutral bloom"—an effect which the great colourists never tried to obtain—and which is really a foster-brother to a cold, or colourless grey.

The eye is the proper judge of colour harmonies, which are the results obtained by the exercise of the judgment and feeling of the artist or decorator, and not by the strict observance of any rigid and meaningless rules relating to the theory of "chromatic equivalents." One colour either in area, or intensity, ought to be in excess of any other colour in a good composition; this will give piquancy and character to the whole arrangement, and will relieve it from the commonplace monotony which is usually found in colour schemes that are based on the optical balance of chromatic equivalents; it is, therefore, not necessary, for the reasons we have stated, to aim for the maintenance of an optical equilibrium, or neutralization of colour, in pictorial or in decorative work, in order to obtain harmony.

It goes without saying, that in all colour harmonies we must have *contrast*, and that the "Harmonies of Analogy" and of "Contrast" are both harmonies of *contrast*. Chevreul and others have taken great pains to divide these harmonies into six different kinds, giving three to the

"Harmony of Contrast," and three to the "Harmony of Analogy," but these six subdivisions are so closely related in general characteristics, that for all practical purposes it would be much simpler and quite as effective to include them under two heads, or in two kinds of colour harmonies, namely, that which is provided by the contrast of tones of closely related colours, or the tones of any one colour, and that obtained by the contrast of distant tones, or colours opposite, or nearly so, in the chromatic circle. We shall then have left some transitional positions on the chromatic circle where certain colours, or tones of colour, will lie, apart from each other, something less than 90°, and, as a general rule, colours that are not removed to a greater distance than this from each other, when placed together, will make poor combinations, but colours removed from about 90° to 220° in distance, on the chromatic circle, will help each other in the matter of harmonious contrast, even if they do not always make perfect arrangements. For instance, red and its complementary green-blue, or purple and its complement green, though opposite, or each pair 180° apart in the chromatic circle, make strong but harsh combinations with each other; these pairs of colours are. however, seldom used together by artists in the full strength of their normal hues, but when darkened or mixed with grey they afford good combinations, and used in this way their great contrasting powers prevent their modified tones from injuring each other. (See Plate 7.)

THE SMALL INTERVAL AND GRADATION OF COLOUR.

Belonging to the harmony of analogy, or to the concord of closely-related tones, is the gradation of colours, where they are separated from each other by a little distance or space in the prismatic band, or chromatic circle; this kind of colour gradation is known as the *small interval.*

In the colouring of natural objects and in natural phenomena we have numberless instances of the small interval. It may be seen in the gradated colours of flowers, in the grey-greens of tree foliage with the tender blues of the sky, in masses of foliage, in the colouring of sunsets, and in birds' plumage, insects, shells, and precious stones.

In the small interval we have the tints or shades of closely related colours arranged in delicate but decided contrasts, such as a green-blue passing into a violet-blue, by a gradual but distinct series of tones, and this is in direct opposition to the effects produced by the bolder contrasts of opposite or complementary colours. We cannot well use gradations of blue and yellow, or red and blue-green, and tone them off in a series of shades into each other, without producing an unsatisfactory and unnatural effect; they make much better combinations when used simply as opposing contrasts. We find that nature always unites warm and cold colours together by the connecting tones of intermediate colours, so that there can be no such a thing as a satisfactory union by gradation, between two

complementary colours, without the employment of a third or intermediate connecting colour.

The following is a table of "small intervals," where it will be seen how the hue of each colour is modified by light and darkness, the effects or changes of hue being similar to those produced by slips of coloured glass when laid on each other in layers of two or more slips, which have been described at page 9 in the first chapter.

Table of Small Intervals.

HUE.		LIGHTER.		DARKER.
Red	is	orange-red	is more	purplish.
Orange-red	,,	orange	,,	red.
Orange-yellow	,,	yellow	,,	orange-red.
Yellowish-green	,,	greenish-yellow	,,	green.
Green	,,	yellowish-green	,,	greenish-blue.
Green-blue	,,	green	,,	bluish-green.
Cobalt blue	,,	cerulean blue	,,	ultramarine.
Ultramarine	,,	cobalt	,,	blue-violet.
Violet	,,	purple	,,	pansy-purple.
Purple	,,	crimson	,,	purple-violet.

In illustrating the above sets of hues with pigment colours it must be borne in mind that in order to obtain good representations of the small interval it will be necessary to get the tones or strength of each colour in harmonic gradation from light to dark; for instance, in the case of cerulean blue, when used next to the cobalt blue, the tint must be pale, or medium, rather than deep. It will also be understood that pale or broken tints, and darkened shades of each set, can be used with great advantage in decorative colour schemes.

Gradated Tones of Broken Red. An example of the Small Interval in Colour.

V. BROOKS, DAY & SON, LTD., LITH.

Harmony of Analogy in Broken Orange and Yellow-Brown.

V. BROOKS, DAY & SON, LTD., LITH.

A series of illustrations in colour are shown on Plates 9 to 12, which are intended as some practical applications of the small interval, combined with gradation of tones. It will be seen that the colours on all these plates are broken with grey, which renders them more useful as background colours, whether as tones for wall decoration, or for other purposes, such as grounds and colours for the ornamental decoration of fabrics, paper-hangings, etc., or as tones of colour that might be effectively used in combination for the painting of doors, windows, and panelled woodwork. Any two of the lighter, or darker colours of each diagram might be used for the painting of woodwork.

Plate 9 illustrates an arrangement in gradated tones of a broken red, the tints of which are mixtures of Indian red, orange-chrome, and white, in different proportions. If a warmer effect were desired, Venetian red might be used instead of the Indian red.

The combination colour on Plate 10 is a harmony of analogy in broken orange and yellow-brown, the dado, or lower colour, is a yellow-brown that accords, by analogy, with the larger space of orange colour. The colours used in this plate are orange-chrome, lemon-chrome, raw amber, and white ; but white is not used in the dado colour.

An example of the small interval in broken blue, or grey-blue, is shown on Plate 11, which also illustrates the gradation of tone. The colours used in the preparation of this diagram were mixtures of ultramarine blue, Prussian blue, lemon-yellow, and orange-chrome with white.

Plate 12 shows an arrangement of broken green, and broken blue-green tones relieved with small fillets or lines of broken yellow, and, although there is here presented a greater variety of colours than on any of the other three plates of this series, still this arrangement may be offered as an illustration of the small interval, for it shows the use of the latter in decoration, as the chief colours in the diagram are closely related to each other. The larger central space is occupied by a green which is closely allied to the green of the dado, and the turquoise of the frieze and dado border, though bluish in hue, does not prevent the whole arrangement from offering a harmony in the broken greens.

We see this kind of gradation or small interval in the green foliage of trees, where the lighter greens are yellowish, the middle tints of the masses greener, and the darker tints inclining to blue- or grey-greens, though the latter are never absolutely cold in hue.

When using tints or shades of green in large spaces in decoration, it is always much better to keep the lighter tints purer in colour, and the darker shades more grey in hue. This is a lesson from nature which can be applied in decoration with the best results. With other colours this is more or less true, but it applies particularly to green, because it is the most difficult of all colours to manage, either in pictorial or decorative art.

There is no quality of colour in nature, or in art, so precious as that of *gradation*, and none so universal; it is gradation which gives the palpitating and throbbing life to

Harmony of Analogy in Broken Blues.

V. BROOKS, DAY & SON, LTD., LITH.

Example of the Small Interval in Colour Tones.

V. BROOKS, DAY & SON, LTD., LITH.

colour, in fact it is the life itself of a colour. Compare the flat uniform layer of a wash, or coat of colour, with a wash of the same colour laid on unevenly, or allowed to flow freely from the brush, and the greater beauty and superiority of the latter will at once be self-evident.

In copying the flat surface of any natural or artificial object that may have a uniform tint of any single colour, such as a sheet of white or coloured paper, the artist knows that he cannot possibly give a true representation of such by a flat wash of colour, but in order to make a faithful copy of the original, he must not only gradate the colours in his copy by a series of almost imperceptible changes of tone, to represent the delicate differences of the lighter and darker portions of the surface, but he must also change the hue of his tints to match the warm or cold tones of his model, for the white or coloured surface of the original will change in tone, or in hue, in accordance with the way in which the light strikes it. So it amounts to this, that when copying the uniform colour of any flat surface, we must not copy the local colour, but the colours given to it by the play of light, a practice which must be observed in all faithful representations of nature. The local colour of an object, in light, is therefore an illusory quantity, which varies with the quality of the light, or the hour of the day, in which it is seen.

If this be true of the colour and tone of a flat sheet of paper, or surface, it will be evident that in slightly curved or in fully rounded surfaces, and in hollows or depressions

of nature, there will be an endless variety of colour tones needed to give a true representation of the changing effects of light and shade on natural objects.

The diagrams on Plate 13 are intended to show the difference between flat and uniform tints of red, and of green, as at A, and washes of the same colours, with a full brush, the colours being allowed to run freely, so that the effect of gradation may be obtained, as in the diagram B. It will be seen that the colours in the latter figure are much more lively and interesting than the uniform and bald expression of the same colours in the figure A.

The changing and tremulous tints of colour that follow each other in orderly succession, and that pervade the whole domain of nature, are due to gradation. The bright blue of the upper regions of the sky is changed by imperceptible gradations to delicate blue- and green-greys, and lower, to the yellowish tones of the horizon that are continually altering, even while we look at them. All effects of the wonderful beauty and liquid softness seen in the landscape under a sunny, or a grey sky, are, of course, due to the quantity and delicacy of perfect colour gradations.

Gradation of colour plays a more triumphant *rôle* in the successful production of a painted landscape than the expression of the finest harmonies of contrasted colours. The flowers and leaves of a plant generally accord in colour, but it does not follow, if it were possible to obtain the general colour of a flower and its leaves, that the two colours would harmonize, without a considerable modifica-

Flat and Uniform Application of Colours at A,
and Gradated Effect of the same Colours, used with a Full Brush at B.

V. BROOKS, DAY & SON. LTD., LITH.

tion of the tones. Take, for example, the pink of the rose and the green of its leaves, or the colours of the carnation and its leaves, the contrasts are strong in the natural plants, the colour harmony of both examples is perfect; paint then a general tint of each colour side by side, and it will be seen that the results are not concords. It is easy to account for this; in nature the harmony is obtained by the subtle gradations of tone and hue, in both reds and greens, caused by light, reflected and transmitted from, and through petals and leaves, and so we have in flowers and their leaves, instead of one or two colours, a multitude of colours and numerous gradations of each, all of which combine to complete the harmony. Applied colours in pottery painting, in stained glass and enamels, afford excellent illustrations of gradation in colour. The accidental effects where the fused colours have "run" in the firing process give an added beauty to works of this description, which enhances their value as works of art, simply because they appeal to us as closer imitations of the gradated colours of nature, being more "alive" in appearance than objects which present an intolerable flat and uniform layer of surface colour.

It is infinitely better, where possible in decorative art, to employ colour in such a way as to obtain gradation of tint and shade, but there are instances where the decorator is obliged to use his colour in uniform and flat tints, as in house decoration, and in the block-printing of textiles and paper-hangings. In textiles, the large surfaces of colour

are broken into various tones and shades by the texture and folds of the material. In velvets and silks especially, when of one colour or two tones of a colour, as in damask effects, the necessary gradation is obtained, but on walls and on other flat surfaces the monotonous effect of uniform colour can only be helped by the design of the superimposed ornament, in which one or two harmonious colours may be interlaced or woven in such a way as to gain beautiful effects, either of analogous or contrasting hues, without injury to the architectural flatness of the surface. Sometimes a coloured design for a textile, that is painted in flat tints on paper, may not look particularly well or interesting on the paper, but when it is carried out in the cloth it may be immensely improved by the aid of the lustre, and the play of light and shade in texture of the material.

Another method of obtaining gradation of colour in pictorial art is seen where little lines or dots of different bright colours are placed side by side, so that at the proper distance they will appear to blend together, and produce not only gradation of colour, but new colours, by mixture on the retina, which will resemble the purer colours of light. When contrasting colours are used in this way, and seen at a nearer distance than that required for their complete blending, a kind of dazzling or lustrous effect is produced on the eye, which is of a similar effect to that given by metals and polished surfaces of wood or metal, where the colour of the material is seen through another colour,

generally bluish, which is reflected from the shining surfaces. The two or more colours thus seem to be seen at once, as if one colour was seen through the other, the effects, of course, changing according to the position of the spectator.

Italian, and Hispano-Moresque pottery of the fifteenth century, afford some of the finest effects of lustre in colours, which is due, as we have mentioned before, to interference colours produced by the action of the light on the metallic oxide glazes of their surfaces.

In connection with the lustrous effects of colour in painting we might mention, among others, the works of the modern Italian painter, the late G. Segantini, who died in 1899. The method of work adopted by this painter was the laying on of a series of very rich and brilliant colours in narrow, parallel, and broken lines, using the paint in thick streaks of prismatic and contrasting hues, placed side by side, so that when viewed from a distance of two or three yards the colours appeared to blend, like mixtures of coloured light, and an extraordinarily rich effect of colour was obtained. The little furrows or hollows, between each ridge of thick but rich colour, appeared darkened when seen close to, but at the proper distance the colour of one ridge played or radiated on the different colour of its neighbour, so that in many cases a new colour would present itself in the hollows between the ridges. The general effect in this painter's work is more like that of translucent enamels, than paintings in oil-colour, which

is owing to his method of execution as much as to the selection of his colours.

There is now a strong tendency with many modern artists to use their colours very pure, and almost prismatic in hue, especially in landscape painting. The works of the French painter, Claude Monet, and some of his followers, are characterized by extreme brilliancy of tone, their methods of execution consisting of the placing of small portions of pure colours side by side, and allowing them to mix on the retina of the eye to form tints and shades. They regard "local colour" as a thing that is almost non-existent, and seek to represent the colours only that light and atmosphere give to the works of nature. They aim at representing shade, or shadow, not so much as an absence of light, but as certain spaces where a lower illumination is represented in a variety of darkened tones of pure colour, consequently they banish dull browns and blacks from their palettes, and the result is that the general appearance of their work is brilliant and iridescent, due in a great measure to the beauty of colour in the shadows.

CHAPTER VIII

COLOUR COMBINATIONS IN PAIRS, TRIADS, AND TETRADS

We propose in this chapter to give a series of colour combinations in pairs, or dyads, in sets of three, or triads, and combinations of four colours, or tetrads. It is not claimed that each combination is a model of perfect colour arrangement, but the decisions arrived at are the results of observation of colour combinations in pictorial and decorative art, and from extensive experiments made with the colours themselves. All the combinations given and described in this chapter have been tested by the writer in water-colour, or in *gouache* pigments, the latter being pigments prepared in *body* colours, which dry with a *mat* or *dead* surface. It must also be remembered that it depends greatly on the way in which most of the combinations are used, for the greater success, or perfection of the colour harmony; for example, take the spectral red with blue, which makes a good combination of colour, but if we employ these colours in flat tints in an ornamental composition, on paper, the combination will appear commonplace and uninteresting, while the same colours seen together in a silk or velvet fabric, in enamels, or in stained glass, will

appear quite different, and their value will immensely increase as harmonizing colours, by reason of the gradation of each colour, afforded by the texture, light and shade, and transparency of the materials.

The colours named below are intended to be those that approach as near as possible in hue to the colours of the spectrum.

Table of Combinations of Dyads, or Pairs of Colours.

Red with	blue	very good.
,, ,,	green	harsh.
,, ,,	yellow	moderate.
,, ,,	orange-red	moderate.
,, ,,	blue-green	fair.
,, ,,	green-yellow	fairly good.
,, ,,	violet	bad.
Scarlet or vermilion with	blue	good.
,, ,, ,,	turquoise	good.
,, ,, ,,	green	harsh.
,, ,, ,,	yellow	moderate.
,, ,, ,,	violet	bad.
Orange-red with	blue	good.
,, ,,	turquoise	good.
,, ,,	blue-green	harsh.
,, ,,	yellow-green	moderate.
,, ,,	yellow	moderate.
Orange with	blue	excellent, but powerful.
,, ,,	turquoise	excellent.
,, ,,	green	fairly good.
,, ,,	blue-green	good.
,, ,,	violet	fairly good.
,, ,,	purple	moderate.
Orange-yellow with	blue	excellent.
,, ,,	turquoise	fairly good.
,, ,,	blue-green	moderate.

Orange-yellow	with	red	poor.
"	"	violet	good.
"	"	purple	fairly good.
Yellow	with	blue	good.
"	"	turquoise	fair.
"	"	blue-green	bad.
"	"	green	moderate.
"	"	red	moderate.
"	"	violet	excellent.
"	"	purple	good.
Greenish-yellow	with	blue	good.
"	"	turquoise	poor.
"	"	blue-green	fair.
"	"	green	fair.
"	"	red	harsh.
"	"	violet	excellent.
"	"	purple	good.
Green	with	blue	poor.
"	"	turquoise	bad.
"	"	red	strong and harsh.
"	"	violet	moderate.
"	"	purple	harsh.
Bluish-green	with	scarlet	fair.
"	"	blue	bad.
"	"	violet	good.

Many of the combinations given above as "moderate" and "fair" can be much improved by darkening the lighter colour, and where they are mentioned as "harsh" they may be brought into better harmony by darkening both colours.

Most of the bad or poor combinations may be made into agreeable harmonies when a third colour is added to the group, which, on the other hand, may shatter the harmony of a pair that combine well together. Thus

yellow with blue-green is a bad combination, but if violet is introduced the arrangement is excellent. Scarlet and blue are a good pair, but if green or greenish-blue is added to make a triad, the combination will be disagreeable.

We had noticed in Chapter VII that in good combinations the colours are generally from 90° to 220° apart on the chromatic circle, thus, red with blue, and yellow with violet, or purple, are combinations in which each contrasting colour is more than 180° apart from each other. This distance prevents them from having the excessive amount of contrast seen in the harsh combinations of red and blue-green, or of purple and green, which are complementary pairs, and whose positions are 180° apart, or directly opposite each other in the chromatic circle.

If the reader will turn to the coloured diagram of complementaries on Plate 7, he will see an illustration of what has just been described in the preceding paragraph, and he may notice that the colours from, and including, violet, at I, round by the lower left hand to yellow-green, at D, are what artists call the *cold colours;* and those from, and including, purple, at J, to greenish-yellow, at C, are the *warm colours;* the latter are also known as *advancing* colours, and the former as *retiring* colours. Orange and yellow are the most advancing colours, and violet and blue the most retiring.

It will also be seen in this diagram that the warmer colours have the colder colours for their complementaries, or opposing colours, and that from an artistic point of view

the opposite pairs are strong, but harsh in combination, but if each colour is combined with the colour that is next to its own complementary, beginning, say, with the orange-red at A, and going round the circle from right to left, the combination of each new pair is more agreeable; for example, the orange-red at A is more agreeable in combination with the turquoise at G, than it is with its own complementary, the blue-green at F, and the greenish-yellow, C, with the violet, at I, is a better combination than the former with ultramarine. The orange, at B, on the other hand, makes an excellent, though powerful, combination with the ultramarine. The yellow-green at D, with purple at J, is a better arrangement than the latter with its complementary yellowish-green at E.

According to our rule, the green at E would have the orange-red, A, for its companion, and although this pair is not so good as orange-red with turquoise, still the arrangement is better than the orange-red and blue-green pair.

We have, so far, endeavoured to point out that many agreeable combinations of colours in pairs may be obtained by selecting for the companion of a given colour, the colour, or it may be any tone of the colour, that is found a little further removed in the chromatic circle from the complementary of the given colour, and it will be evident from this, that if the number of colour tones were increased to any desired extent, in the chromatic circle, and represented in a coloured diagram, we should be enabled to pick out corresponding numbers of agreeable colour combinations in

pairs, most of which would belong to the "Harmonies of Contrast," that is, each colour of any pair would have the helpful contrast of its neighbour, because they would not be very far removed from being true pairs of complementary colours.

There are some other ways by which poor or bad combinations of colours may be rendered more agreeable; one is, by using them in strong light and shade effects, another by gradating each colour in different tones of itself, and another by considerably decreasing one of the colours in area, or intensity of hue.

The preponderance of a cold colour, or the use of positive greens in large masses, are some of the causes which make colour arrangements look repelling and disagreeable. Cold colours in large quantities, unless used pale and pure, have always a bad effect, and are generally avoided by good colourists. Pure and positive greens, and strong violet colours are always irritating to the eye, the former especially so. A picture or a decorative composition can easily be killed by an over-dose of green; but, on the other hand, small quantities of bright green are valuable, and have a stimulating effect in colour compositions, when judiciously used in pictorial or decorative art.

The list of pairs of colour combinations described in this chapter were confined to the purer or brighter colours, but the colours mostly used in painting, and especially in decorative art, are generally those that are composed of modified or broken tones.

To give many of the latter kind of colours a name is almost impossible, for the hues and tints of some of the most beautiful colours in broken tones are quite indescribable, we might as well try to number the stars in the midnight sky, as to give correct names to the numberless legions of broken colour tones; as it is, we must be content with naming some of them after something that has an approximation to them in colour, in the animal, mineral, and floral kingdoms; but the exhaustless and varying tints and shades of each render the task of colour classification and nomenclature quite hopeless, and we must be satisfied with approximate designations. Take for example the very common colour term, "rose-pink," who can describe or number its varieties? It may be a colour that approaches to crimson, purple, or even to a red-brown in depth, or it may be composed of different tones of a crimson-red and yellow mixture, or it may be only a kind of white having a pale blush of red—the progenitor of a rose-grey. Some pale rose-pinks have so much yellow in their composition that they might be classified as "yellowish-pinks," which are some of the loveliest tints of the rose. The beauty of a "coral-red" will depend on the exact amount of grey it may have in its composition.

For illustrations of some of the many harmonious dyads, or pairs of colours, we may go to nature, or we may find them in many examples of good ornamental art; in some of the latter arrangements the colours used are often the result of accidental grouping, but when found to be success-

fully combined, it will be seen that they have conformed to some natural law of colour harmony, and we may notice that many of these are traditional harmonies, used over and over again, as, for example, the various tones of orange with broken blues, soft reds with grey-greens, lavenders and lilacs with warm yellows, and medium violets with pale yellow-greens, etc.

Greens with blues are cold combinations as normal colours, but we often see in nature that "blue is married to green in all the sweetest flowers," in the bluebell, the lobelia, the forget-me-not, and in that "queen of secrecy," the violet. It must be remembered, however, that in none of these flowers do we ever get blue and green in their pure state, but in broken tones of each, which are so useful in ornamental art. There is also another, and very important element that helps the colour harmony of nearly all blue flowers, and that is found in the yellow or orange-coloured centres, which consist of the pistils and stamens, and although, at a distance, these small specks of contrasting colours are hardly visible, on a closer inspection their effect with the bluish petals is exceedingly harmonious. The pale blue of the forget-me-not and its pale orange centre make a perfect harmony.

With a knowledge of the complementary colours, whether of the primaries and their secondaries, or of the broken colours of each, we are enabled to obtain almost endless combinations of contrasting pairs, which may be modified in tone or scale by mixtures of white, grey or

Agreeable Contrast of Plum-Violet and Sage-Green.

V. BROOKS, DAY & SON, LTD., LITH

black, and in experiments for this purpose the rotating apparatus, with Maxwell's colour-discs, can be used with great advantage.

We give below a selection of colour dyads forming agreeable combinations, some of which have been selected from various arrangements of colour in textiles, tiles, enamels, pottery, and other decorative work, and some are the results of experiments.

TABLE OF AGREEABLE CONTRASTS.

1. Heliotrope and light amber.
2. Violet and amber.
3. Violet and light yellowish-pink.
4. Ultramarine and dark yellow-green.
5. Grey-blue and light golden-ochre.
6. Plum-purple and orange-amber.
7. Plum-violet and sage-green.
8. Brownish-yellow and deep warm green.
9. Dull orange and slate-blue.
10. Dull indigo and dull orange.
11. Slate-blue and greyish-yellow-green.
12. Claret and buff.
13. Deep blue and yellowish-pink.
14. Chocolate and pea-green.
15. Maroon and warm green.
16. Black and bronze-yellow-green.
17. Deep red and medium grey.
18. Venetian red and grey-yellow-green.
19. Coral-red and turquoise.
20. Chamois and lavender.
21. Deep crimson and yellowish-green.
22. Deep golden-yellow and sea-green.
23. Golden-brown and olive-green.
24. Pale turquoise and pale orange.
25. Deep blue and yellowish-green.
26. Indigo and light olive-green.

All these colour combinations would be improved if the colours were divided by lines of black, white, gold, or in some cases by a neutral grey.

An illustration of the pair, number seven on the list, namely, plum-violet and sage-green, may be seen in the

diagram on Plate 14, where these colours will be found in agreeable combination.

In the diagram on Plate 15 there is an arrangement of three colours, namely, slate-blue, broken, or greyish-yellow-green, and dull orange; these colours as a triad, or group of three, go well together, but the dull orange with the slate-blue, without the green, make an excellent combination, which illustrates number nine on the list, and this pair may be seen in the buds, at the lower part of the design. The slate-blue and the greyish-yellow-green of the background in this diagram—number eleven on the list—also make an agreeable harmony of contrasting colours.

To arrange colours in triads, or groups of three, that will offer agreeable combinations, is a much easier task than the construction of harmonious contrasting pairs, but the range of agreeable triads is more limited, for it is obvious that the possibilities of the chromatic circle are lessened, the more we multiply the colours in combination.

We have seen previously in this chapter, that any two colours, no matter how disagreeable they may look together, may be brought into harmony by the added help of another colour in combination, and, generally speaking, it is not a very difficult matter to obtain the colour that is wanted to complete the harmony. The chief thing to observe in the selection of any three colours, necessary to form an agreeable arrangement, is that each colour, or tone of a colour, should be selected from equally distant, or nearly so,

Combination of Broken Colours of Green, Blue and Orange;
Harmony of Contrast.

V. BROOKS, DAY & SON, LTD., LITH.

positions on the chromatic circle, and what is almost of as great importance, is to have *two* of the colours in the arrangement selected from the group of the *warmer* colours. Not only do these conditions obtain in the natural laws of harmonious colouring, but we constantly notice this preponderance of warm colours over the colder ones, in the best colour schemes of the great colourists and decorative artists.

The old mosaics of the fifth century at Ravenna have colour arrangements of blue, gold, and green; the green is yellowish in the lighter parts, and is gradated into the blue ground, in certain parts of the design, and here the gold supplied the place of red or orange, the whole being a perfect harmony.

The favourite triads of the best Italian painters were—

Red, blue, yellow.
Coral-red, ultramarine, orange-amber.
Scarlet, olive-green, violet.
Orange, green, violet.
Purple, yellow, grey-green.

In all these groups it will be seen that the warmer colours are in the ascendency, and each of the triads afford excellent colour combinations. The last group of the series was a favourite one with some of the early Italian frescanti, and may be particularly noticed in the frescoes of Perugino.

The following groups of colours arranged as triads afford agreeable combinations—

1. Red.
   Yellow or gold.
   Blue.
2. Blue, medium.
   Turquoise.
   Orange-yellow.
3. Olive-green.
   Blue, dark.
   Amber, deep.
4. Orange.
   Grey-blue.
   Cream-colour.
5. Orange-red.
   Blue-green, dark.
   Yellowish-green, dark.
6. Crimson, deep.
   Stone-colour, dark.
   Greenish-yellow, darkened.
7. Crimson, deep.
   Leather colour, light.
   Blue, medium.
8. Purple.
   Pale orange.
   Green-blue.
9. Grey-blue.
   Amber.
   Greenish-gold.
10. Violet.
    Orange-yellow.
    Green.
11. Ruby-red.
    Blue, deep.
    Greenish-gold.
12. Scarlet.
    Olive-green.
    Violet-blue
13. Purple.
    Yellow.
    Grey-green.
14. Lavender.
    Orange, dull.
    Yellowish-green.
15. Venetian red, dark.
    Chamois, deep.
    Sea-green.
16. Indigo.
    Orange-red.
    Greenish-yellow, deep.
17. Leaf-green.
    Orange, pale.
    Pink, pale.
18. Coral-red.
    Ultramarine.
    Orange-amber.

The colours of these triads may, of course, be used with better effect if some, or all, in each group be gradated in two or three tones, and if black, white, or grey be added as outlining colours, in cases where these combinations are used in decorative designs. Deeper or lighter tones of the colours in each triad may, as a general rule, be used with fairly good results.

Harmonic Balance of Warm and Cold Colours.

V. BROOKS, DAY & SON, LTD., LITH.

Regarding the use of gold in decoration it might be said, that when used otherwise than in grounds, it is better to have small quantities of it placed in certain important positions, or to use it for very thin outlines of the ornament. If not used sparingly, as becomes its precious nature, it will look meretricious and vulgar. If it is used as a ground for decoration, it looks always best when the ground spaces are very small in area, and then it should always be toned or glazed with thin films of siennas or greenish-browns, if the surface to which it is applied is not extremely roughened. Except in the case of moulded fillets, gold should never be applied to smooth surfaces in architectural decoration. Coloured ornaments on gold grounds should always have thin outlines of black, white or dark rich browns, or else the gold of the ground will overpower the colours and make them look poor.

Plate 16 illustrates an arrangement where there is a balance of warm and cold colours ; the triad is composed of an orange-red, a dark blue-green, and a greyish-yellow-green ; the last two colours are broken with a small quantity of grey ; the blue-green is a cold colour and occupies less space in the design than that of the combined areas of the other two, so that the warmer colours predominate. The value of white as an outline is expressed in the design.

Complex colour arrangements in decoration do no possess much more value than those in which three or four colours are used, unless the various colours of the combina-

tions are simply different tones of the principal colours, or of closely related hues of the latter, as in illustrations of the small interval. Decorative designs look better when the colour arrangement is kept as simple as possible, and the colours few in number, provided that they maintain their distinctive character, or, in other words, do not suffer injury by harmful contrast. (See table of combinations of dyads, pages 87 and 94.)

The following is a list of tetrads or groups of four colours which may be found useful as agreeable compositions in decorative colouring—

1. Red. Chamois yellow. Grey-green. Bluish-green.
2. Blue. Red. Violet, medium. Gold.
3. Crimson. Grey-green. Pink (greyish). Straw-colour, deep.
4. Maroon. Olive-green. Pale amber. Sea-green.
5. Blue. Gold. Blue-green. Amber, dark.
6. Violet-purple. Amber-red. Ultramarine. Olive-green, dark.
7. Grey, dark. Red. Sea-green. Greenish-yellow.
8. Indigo. Citrine yellow. Grey-blue. Olive, warm.
9. Pea-green. Slate-blue. Venetian red. Pale orange, greyish.
10. Lemon-gold Turquoise. Venetian red. Blue-green.

Design showing Analysis of Colour in a Peacock's Plumage.

V. BROOKS DAY & SON. LTD. LITH.

11. Orange, pale. Blue, dark. Turquoise. Warm white.

12. Ultramarine. Jasper red. Dull gold. Blue-green.

Many complex colour arrangements of great beauty are found in the wings of moths, butterflies, and in other insects; the plumage of birds, shells, rocks, minerals, and precious stones are rich in complex colour harmonies. The sunset hues and the colours of many flowering plants, autumn foliage, and the common weeds of the field, afford numerous examples of harmonizing colour schemes. The tranverse section of the tourmaline gem displays a colour harmony in rose-pink, pale blue, emerald, and russet-gold, and in many other precious stones we see beautiful illustrations of the gradated colours of the small interval, among which may be mentioned the amethyst, with its violet colours changing to purple hues, the sapphire from pure blues to aquamarine, and the dusky topaz from amber-yellow to golden-brown.

The design on Plate 17 is a complex colour arrangement, the colours of which have been suggested from some of the many hues of a peacock's feather. There is nothing in the proportion, or arrangement of the colours here presented, that accord in any way with those of the colours in the natural feather, the illustration is only given as a bright colour combination of contrasting tones, selected from or suggested by the colours in the natural specimen. If the colours here shown were each presented in gradated tints,

instead of the comparatively flat treatment seen in the design, the effect would of course be infinitely richer. The dull pink colour in the design is treated in a flat uniform tint, and is in harmony with the other colours, but in the natural feather this colour changes according to the position in which it is seen, or to angle of light, from pink into a coppery gold.

CHAPTER IX

HISTORICAL DEVELOPMENT OF COLOURING IN ART—EGYPTIAN COLOURING

THE use of colour in decorative art dates at least from the dawn of the earliest historic periods. It would be safe to say that the first attempts in colour arrangements were those effects produced by the weaving of different kinds of grasses and strips of bark together to form mats for clothing and other purposes.

We know that some of the very earliest examples of colour arrangements in ancient Egyptian decoration were copied from the designs and patterns of woven mats. Coloured bricks and small discs of coloured clays have been used in the formation of these patterns, and specimens of this work have been found in some of the oldest tombs and pyramids in the valley of the Nile.

The Egyptian, Chaldæan, and Assyrian coloured decoration, or indeed that of any primitive nation, is not *painting* in the proper meaning of the word, but must be considered as decorative *illumination.* Even in their highest artistic efforts, as in the design and colouring of the human figure and animals, the treatment adopted was

the illumination in colour of flat surfaces, and consequently they relied on well-balanced contrasts of colour for artistic effects. Considering the limitations of their colour range and methods of execution, it is remarkable how well they managed to obtain and preserve the fine sense and expression of colour harmony which generally characterizes their work.

The colours used by the ancient Egyptians were the pigments and tints of yellow, red, blue, green, brown, black, and white. The yellows, reds, and browns were obtained from the ochre earths; the bright blues were mineral colours, composed of copper, sand, and a subcarbonate of soda. Some colours used were of vegetable origin, such as indigo. Ultramarine from lapis-lazuli was also used by the Egyptians, and was imported from Central Asia. The greens were mixtures of blue and yellow; blacks were obtained from carbonaceous substances, and whites were made from lime and gypsum, and from powdered enamels. Gold, applied in leaf, was also used in decoration.

Egyptian colour combinations have a distinct character of their own that is quite different from the colour arrangements of any time or country, and if we examine the causes which have produced this individuality, we shall find that the Egyptian decorator invariably arranged his colour schemes in a few traditional combinations, which have for thousands of years been repeated over and over again, with little or no changes; for example, he used

black largely to outline his ornamental forms, and in wide and narrow bands to separate red, blue, or yellow. White was also used in similar ways, and again white was used as an alternating colour to separate blue, red, yellow, and green, without any black in the arrangement, this being one of the commonest colour combinations. Blue and white alone, or two shades of blue with white, occur frequently in lozenge-like diaper ornament.

The following colour combinations in triads are very common in Egyptian decoration—

Black, yellow, red.
Red, blue, white.
Dark blue, light blue, white.
Cream-colour, blue, black.
Dark red, medium yellow, dark turquoise.

The under-mentioned tetrads, or groups of four colours, are also frequent—

Red ochre, green-blue, yellow ochre, black.
Black, blue, green, red.
Red, green, blue, white.
Black, white, red, yellow.
Black, white, turquoise, bright yellow.
Pale orange, turquoise, dark rich blue, warm white.

The last two combinations and the last-mentioned triad are generally found in the enamel colours of Egyptian glass bottles, tiles, bricks, and beads. The last-mentioned combination of four colours is peculiarly oriental, being also found in the Assyrian and ancient and modern Persian pottery and glass. It is undoubtedly one of the best, if

not the finest colour harmony that has been used for the decoration of glass objects, tiles, glazed bricks, and other forms of pottery. The cool arrangement, without being absolutely cold, that these colours give in combination, is admirably suited for tiles and pottery decoration, and the brilliancy of their hues is augmented by their use as enamel colours and by the surface glaze. The other combinations given above were used in the distemper decorations of the walls and ceilings of tombs, and on the mummy-cases.

In complex colour schemes the Egyptians very often used all the colours known to them in combination, generally in their purity or full strength, but sometimes in tints or shades of the stronger colours. On some of the mummy-cases there are tints of a pale leaf-green, medium blue, and dark blue, also black, white, brown-red, and different tones of yellow. Gold-leaf, thicker than our modern variety, was extensively used, but owing to the perishable nature of the adhesive substance employed, the gold-leaf, except in hollows and in small patches, has dropped off the surfaces. The explorer Mariette found a considerable amount of gold-leaf, in books, in the tomb of Ka-em-as, the son of Rameses II., and also there were remaining evidences to show that the lower part of the walls in this tomb had originally been covered with gold. The globe in the symbolical figure of the winged globe was often gilded, and the four faces of the obelisks of Hatasu were gilded. Gold-leaf has also been applied to bronze figures and to the masks on the mummy-cases.

The Egyptian methods of colour decoration were usually to prepare grounds of stucco, or lime, or in gypsum (plaster of Paris), by spreading these materials on stone and wood, or on canvas or linen, as in the coverings of the mummy-cases. The outlines of the design in important figure-work were drawn out by the chief artist, and his assistants would follow him in laying on the distemper colours in flat tints between the outlines. The ordinary decorators or artisans would execute all of the geometrical and symbolical ornament. Some of the mummy-cases present a darkened and shiny appearance, owing to the use of some kind of varnish, which has injured the purity of the colours.

The Egyptians, like other nations of the East, had to deal with a bright and dazzling sunshine, and the use of positive and strong colours was indispensable, in order to emphasize the forms and contours of their architecture, therefore strong colour was employed primarily to give the necessary variety to surfaces, to keep the construction clear, and to distinguish the various members of the architecture, which would be, if it were not for colour, almost indistinguishable in the brilliancy of the Eastern sunshine. The positive colouring of the dress material used by natives of the East is not by any means harsh or strong when seen under the intense sunlight, and this suggests a good reason why the oriental has such a fondness for wearing bright-coloured fabrics. If this high degree of intense illumination tends to diminish the saturation and

purity of bright colours, a very low degree of illumination, as in the semi-darkness of Eastern interiors, will modify, by lowering, the tones of the most brilliant colours, so that in the blinding light of the sun, or in the twilight of Eastern interiors, all half-tones or delicate shades of colour would be obliterated, and therefore the oriental colourist is, in a measure, compelled to use his colours in strong and clear tones.

CHALDÆAN AND ASSYRIAN COLOURING.

A distinction might be drawn between the general character of the colour combinations of Egyptian decoration, and that of the nations which inhabited the land of Mesopotamia. The latter people have always had a fondness for the colours blue and yellow, in combination, in preference, but not to the exclusion of other colours, while the decorators of the Nile valley were more partial to arrangements of red, black, and yellow. Both nations used the same range of palette, but we might say that *blue* was the arch colour of the Assyrian, and *red* that of the Egyptian. This distinction affords a key to the cooler schemes of colour we usually find in the decorative work of the Assyrians, Babylonians, and ancient and modern Persians, and to the warmer colour arrangements of the Egyptians, Greeks, and Romans.

The extensive use of blue and yellow with the Assyrians and Chaldæans in their architectural decoration was principally due to the fact that they were mineral colours, and

eminently adapted for enamelling purposes, and were therefore in great request for the decoration of glazed bricks and slabs of enamelled faïence, which were used in great quantities in nearly all of the Assyrian palaces and other buildings in Mesopotamia.

Reds and greens, as well as other colours, were used more especially by these people in the colour arrangements of rugs and carpets, and were generally obtained from vegetable sources. These brilliant dyes, extracted from the mountain plants, have been used by the weavers of Babylon and Nineveh, and the same dyes and the same processes have been handed down from remotest antiquity to the present day.

The Kurd and the Turkoman nomad and peasant weaves to-day the same patterns and in similar colours that have been in use for more than thirty centuries, but every year this ancient and beautiful industry is getting more and more corrupted by the importation of European chemical dyes, inferior designs, and shoddy materials, and unless a renaissance of these ancient arts and methods sets in, the whole artistic industry of carpet-weaving in the East will soon die out.[1]

[1] Modern European and English goods of the most startling and frightful combinations in colour are now imported to the East in great quantities. The writer saw a great collection of these goods at one of the recent international exhibitions, labelled "Pour l'Orient"; the colour arrangements were chiefly crude and harsh grass-greens, flaming crimsons, and "Reckitts" blues. This is an example of the commercial methods of the West in the education of the East in colour harmony.

The blue and yellow enamel colours were prepared from the oxides of minerals ; one of the blues was an oxide of copper, mixed with a little lead, and another was ultra-marine from the lapis-lazuli, reduced to powder, the latter precious stone being imported from Central Asia not only to Babylon, but also to Egypt. The yellow enamel colour was an antimoniate of lead, or a compound of the oxides of tin and lead, which is a similar composition to that of Naples yellow. The red enamels were not of a very bright colour, and were made from sub-oxides of iron, and some, perhaps, from a sub-oxide of copper. The white enamel was an oxide of tin, and the black was probably a graphite or mineral black. Green, which was used sparingly in the Ninevite decorations, was most likely a mixture of the blue copper oxide and the enamel yellow.

Blue, white, and yellow was a favourite triad used by the Assyrian enamellers on the glazed bricks ; the ground colours in most cases were blue, and the figures, animals and ornament, yellow, with a little white. Sometimes the grounds were white or pale yellow, and the decoration in blue. An interesting colour arrangement on a large glazed brick was found by Layard at Nineveh, on which some figures were painted in three shades of yellow. The dresses were in two shades, a brownish-yellow and a lighter greenish-yellow, relieved in places with a little white, the flesh tints were of a still lighter yellow, and the hair and sandals of the figures were blue-black, the whole being on a ground of cream-white. This scheme of colour is quiet,

but exceedingly harmonious, and is an illustration of the harmony of analogy, or of the use of the small interval in colour. It is also an example of one of the nearest attempts to painting, in a pictorial sense, made by the Assyrian decorator, for although each colour is laid on in even tints there is evidently an attempt at the gradating of tones, by the use of the three tints of yellow. The Assyrian and Egyptian decorators never got much further than this in the handling of tones, each colour was invariably laid on in flat tints, and no representation of the succession of planes, by means of light and dark shades, has ever been thought of, or practised. Another excellent colour combination on some glazed bricks from Nineveh, and now in the British Museum, consists of ultramarine blue, pale yellow, red ochre, and black, the blue being used as the ground colour.

Within the three last years a party of German explorers, under the leadership of Dr. Robert Koldewey, have been making some excavations at the site of the ancient city of Babylon, and under the mound of earth and rubbish known as the Kasr-, or "palace"-mound, they found the actual remains of what, no doubt, was the palace of Nebuchadnezzar, the King of Babylon, the destroyer of Jerusalem. The remains covered an immense area; and on the east side of the palace a street was found, paved with two different kinds of stone, and on the blocks of the stone pavement inscriptions were found, stating to the effect that "Nebuchadnezzar, the King of Babylon, son of Nabopolassar, the King of Babylon," had built this highway of

"Mountain Stone" as the street of the "procession" for the great god Marduk, the sun god, and the chief god of the Babylonians. This sacred street was consecrated to the use of the god Marduk, who was carried in procession once a year, on New Year's Day, along this highway from his temple, which was found at the end of the street, to visit the god Nebo, whose shrine was at Borsippa, a suburb of Babylon.

Amongst the remains of the pavement of this street the explorers found a great number of fragments of enamelled bricks, coloured in a similar way, as in the Assyrian bricks, namely, in blues, yellows, and whites, etc. Sufficient fragments were found, so that when they were fitted together they formed a kind of mosaic representation of walking lions on a frieze, having borders of white daisies with orange-yellow centres on a dark blue ground. It is supposed that this frieze, or dado, formed the decoration of the walls on either side of the sacred street, and when *in situ*, it may be imagined that this decoration representing processions of lions, sparkling in the brilliant enamel colours, would present a magnificent appearance in the Eastern sunshine.

A coloured illustration of a portion of this frieze is given in *Harper's Magazine* for April 1902, accompanying an article on "The Palace and Temple of Nebuchadnezzar," by Dr. M. Jastrow, to whom we are indebted for the above information.

This recent interesting "find" puts an end to all doubt,

if any such existed, regarding the origin of the celebrated "Lions Frieze" which was found in the excavations on the site of the ancient Persian palace of Susa by the French explorer Dieulafoy, and which is now in the Louvre at Paris. We give a coloured drawing of a portion of this frieze, copied from Dieulafoy's restoration, on Plate I (frontispiece). The colour and design of the latter are almost identical with that of the Babylonian frieze, except that the lions in the latter and older work have more of a resemblance to nature, but the decorative qualities, and the drawing of the Persian lion, are finer and greater, and the expression of the animal spirit is more virile. We should say that the date of workmanship places the Persian example not more than 100 years later than its Babylonian prototype, and that it must have been designed and executed by a Chaldæan artist, commissioned, perhaps, by Darius, King of Persia (520 B.C.), for his palace at Susa.

PERSIAN COLOURING.

Besides the "Lions Frieze" from the ancient Susan palace, there have been fragments of another, the "Archers Frieze," which have also been found at Susa, and which have been put together, and the whole composition restored by Dieulafoy, a copy of which may be seen in the Museum at South Kensington.

The "Archers Frieze" consists of a row of gaily-apparelled warriors, each with a bow over the shoulder, and

a quiver fastened to their backs. Each carries a long spear in his hand, and each figure is almost a counterpart of its companion in drawing and modelling, for, like the lions, they are modelled in low relief. Their embroidered garments are decorated, one with daisies, and the dress of the figure next with small squares or checkers; by this means, and the alternation or counter-change of colour on the dresses, the monotony, caused by the sameness of attitude of each figure, is considerably diminished. In this frieze the colouring is much darker and richer than in the lions frieze, the blue is more of a green-blue or turquoise, the yellows deepen into orange, and a brown, prepared from ochre and manganese oxides, is used as a flesh tint, and for the colour of the quivers. The ground colour which surrounds the figures is deep turquoise, of a beautiful and uneven tone, partly aimed for, perhaps, and partly accidental, and the dresses are orange and warm white with small portions of green, the whole arrangement making a powerful and rich harmony, which is very characteristic of the enamelled colouring of Persia and the East. Red is absent from this colour arrangement, which is the case in almost all enamels of Assyrian and Chaldæan origin.

The general colour effects of the Susan enamel decorations are extremely artistic, for although the designs are necessarily formal and severe, in conformity with architectural fitness, and the colouring kept within a strict chromatic arrangement, yet we find that the decorator always exercised his own taste and judgment when distributing the

colours in the work, often replacing one colour by another without any apparent reason, according to his own fancy rather than following any particular rule, so that the rigid formality of the pattern or decoration was invariably broken by the interchanging of the hues, or by the use of slightly differing tones of the colours. This artistic treatment could not fail to produce pleasing results, and contrasts favourably with the more mechanical work of Western origin, where colour is applied in measured and uniform quantities, and where the patterns are either moulded or printed, so that all in a series are quite alike, and all expression of the individuality of the artist is obliterated.

In all genuine Eastern art productions, whether in pottery, textiles, metal, woodwork, ivory-carving or glass, the life-training of the artist, or artisan, qualifies and permits him to use his own judgment in the modifying of decorative forms, and particularly his colour treatment, within certain bounds, and allows his imagination free play while he is working out in his own way the typical characters and arrangement of his design. It will be seen from this that the oriental craftsman is more of a true artist than his brother worker of the Western workshops, who turns out thousands of machine-made articles, or manufactured goods, all prim and neat, all of the same form and colour, but all wanting that touch of the imperfect on the would-be-perfect, that gives the humanity and life, or that reveals the presence of the human hand in the workmanship.

The methods and processes employed in the enamelling of bricks in Persia, down to the sixteenth century, were exactly the same as those followed by the Chaldæan enamellers. Large slabs and bricks were decorated and glazed on the surface that was to face outwards, and the designs were generally executed with a raised outline around the units of the patterns; these outlines separated the colours, and added considerably to the rich effect, while at the same time they protected the colours in the hollows from injury. It might be said, if it had not been for the presence of these salient outlines, very little of the colour decoration of these old monuments would have lasted through the centuries of age and neglect.

MODERN PERSIAN COLOURING AND ITS INFLUENCE.

The use of enamelled and vitreous-glazed tiles as a veneer, or surface decoration, of the walls of buildings dates from about the year A.D. 1000; but the lustred tiles, with or without Saracenic or Arabic inscriptions, are of a much older date, probably from A.D. 600, or earlier. Some of these are of a fine copper, ruby, brown, or bronze lustre, obtained from gold and other metals, which were melted and baked into the vitreous glazes. These old lustred tiles have been decorated in blue, white, and black, or brown patterns, or with inscriptions and verses from the Koran.

Some Persian and Damascus tiles, plates and other ware have been enamelled in beautiful colours. The combinations are usually lapis-lazuli, or dark cobalt blue, turquoise, lavender, or pale purple, and white. The ground is of a most beautiful soft white, the ornament is turquoise, and lavender, or sometimes bluish-grey, and the outline is a deep cobalt. It will be noticed that these colours are similar to, and have been derived from the old Chaldæan enamels. Other tiles of Damascus, and Persian plates and bowls, have a soft yellow-green, and an olive green, in addition to some of the former-mentioned colours, and are outlined in a dark grey, nearly black. The Rhodian, or Turkish, tiles and plates have a peculiar heavy Venetian red introduced among the blues and greens, which certainly appears rather aggressive and discordant, though it gives a warmer tone to the colour combination.

We have seen that Persia inherited the traditional designs and colouring of Assyria and Chaldæa, and when the Mohammedans conquered Persia they found in that country a living art, which they themselves learned and adopted from the people they had subdued, and very quickly they spread the art of Persia, in slightly modified forms, through Asia Minor, Northern Egypt, India, Arabia, to the country that is now Turkey, to Sicily, and as far as Spain, in fact, to every country they brought under the Moslem rule, so that in all those countries even at the present day there may still be seen the strong influence of Persian or Saracenic forms and colouring, both in

their architecture and in all branches of their industrial arts.

The weaving of textiles of Persia and Syria, both in carpets and in silk damasks and brocades, was a very important industry in those countries when they came under the power of Mohammed, in the ninth century, and the Saracens did all in their power to foster and develop the Persian textile trades, especially that of silk goods, and silk looms were set up in every country under the Saracenic rule from the ninth to the fourteenth century. They also established silk manufactories in Christian countries, as in Italy and Sicily, and some of the finest designs and colourings in silks were those made in Sicily known as "Siculo-Arabian," and the Italian silks and velvets of Palermo.

Persia was the fountain-head from whence came the best patterns and colour examples, but the patterns were modified or mixed with some other symbolic forms, that were used in the ornament of the different countries; but still the Persian influence is clearly seen in the design and colouring of these beautiful silks and velvets.

A few of the more important or typical colour combinations in Persian and in other silks and velvets, showing Saracenic influences, are here given—

Sicilian Damasks.

Golden yellow	(ground)
Amber-brown	(ornament)
Bright yellow	(ground)
Pale dull purple	(ornament)
Ruby-red	(ground)
Grey-pink	(ornament)
Gold	(ground)
Apricot	(ornament)
Dark-red amber	(ground)
Yellow-green	(ornament)
Dark maroon	(ground)
Green	(ornament)
Gold	(outline)
Grey-blue	(ground)
Pink	(ornament)
White	(outline)
Gold	(in bands)

Persian Brocades.

Maroon	(ground)
Dull gold	(ornament)
Turquoise-green	(ornament)
Crimson-brown	(ground)
Ochre-yellow	(ornament)
Green Dull gold	(in small quantities)
Rich olive-green	(ground)
Dull gold	(ornament)
Dark red White Pale blue	(in small quantities)
Violet	(ground)
Amber	(ornament)
Olive-green	(ornament)
Black	(outline)
Gold	(small portions)

Italian Velvets, Tissues, and Brocades.

Yellow-green	(ornament)
Dark violet	(ground)
Dark blue	(ground)
Light olive-green	(ornament)
Crimson-brown	(ground)
Dull orange	(ornament)
Pale yellow-green	(ornament)
Deep amber	(ground)
Dark grey-blue	(ground)
Dull crimson Pale blue Chrome-yellow	(ornament)
Indigo	(ground)
Purple Sage-green	(ornament)
Gold	(outlines)
Dark grey-green	(ground)
Emerald-green Dull orange	(ornament)
Gold	(outlines)
Dark grey-blue	(ground)
Pale greenish-blue	(ornament)
White Gold	(in small quantities)
Deep crimson	(ground)
Dark blue-green Light blue Greenish-yellow Orange	(ornament)

GREEK AND ROMAN COLOURING.

The primitive Greek decorators, who painted on stucco and in fresco, had only a very limited palette, according to what we know and have seen on the fragments and remains of painted ornaments, flowers, animals, and the human figure that have been found in the excavations among the ruins of some houses and palaces at Tiryns and Mycenæ. The colours used in these decorations, in stucco or fresco, were white, red, blue, yellow, and black, and the colours on pottery were brown, black, maroon, white, and red. Some of the wall decorations that were painted on wood, stone, and plaster, had colour arrangements in a chalky-red, dark brown (a mixture of black and red), pale yellow, and a bright blue. No genuine green colour was found. Another arrangement was yellow and blue, alternating as bands of colour, on which were hatched lines of black; this arrangement formed the decoration of the lower parts of the walls in the sleeping and common rooms of the primitive Greek dwellings, and the walls above were painted in single tints of red, blue, or yellow, with any ornament, but the reception-rooms were elaborately decorated with spirals, rosettes, guilloches, meanders, figures, or animals, and in combinations of all the colours the decorator had at command. The concrete plaster floors and the wooden ceilings were also coloured and decorated. A common floor ornamentation consisted of lozenges and checkers of red and blue, surrounded by a yellow band.

The dado found in the Mycean houses, and in those at other places in ancient Greece, was built of stone, and the upper parts of the walls were of soft brick, the whole being generally plaster in stucco, and afterwards decorated in colours, and very often the practice was to have rather elaborate decorations on the dado, while the upper parts of the walls were left in plain colour; this was also the practice followed in later Greek house decoration, of which the Pompeian houses afford many examples, for the latter, though belonging to the early Roman period, and built on Roman soil, are thoroughly Greek in style of building and in decoration. All the elaborate styles of panelling, dividing of the wall spaces, and extravagant colouring and ornamentation found in the houses at Pompeii, were only developments of a similar practice that originated, and obtained, in the more ancient dwellings of primitive Greece.

Besides the artificial colour combinations in fresco and stucco, these ancient palaces and houses were decorated in natural colour arrangements obtained by the use of green marble, red porphyry, and alabaster stone, the latter being used as frame-work for ceiling-cornices, etc., and in the hollows of the carved stone pieces of a blue glass paste were inserted in the shape of discs, cubes, or small spiral ornaments. Bronze, gold, silver, electrum, and ivory were extensively used in combination with different-coloured woods and marbles, for the decoration of friezes, ceilings, doors, and other architectural features.

The Greeks were extremely fond of colour, and though

fragments only of these evidences of colour have been found, they are sufficient to show that although plastic art and the beauty of form took the precedence as a national bias, they were in no way behind their contemporaries in their use and love for colour, and the coloured fragments are also sufficient to confirm Homer's descriptions in the *Iliad* and the *Odyssey* of the palace of Alcinous, and the house of Menelaus, with their brazen walls and golden door, the silver, ivory, and enamel-blue of their lintels and entablatures. Traces of brilliant colouring have been found on the temples of the best periods, though the colours on the Greek vases are mostly confined to black and terra-cotta hues. The women of Ionian Greece were famed for their embroidery in rich colours, or in "painting with the needle" with gold and blue and Tyrian purple, which they had learned from the famous embroiderers of Phrygia and Lydia.

Roman colouring was but a development of the Greek, as the case was with nearly all kinds of Roman art. Guilds or schools of painters and decorators existed in all Roman cities, the master of the guild was a Greek artist, and most of the members would be of Greek birth. The master would design and execute the principal part of the decoration and wall-pictures, the minor parts being left to the assistants under his supervision.

The chief characteristics of the decorations from a colour point of view are the dark and rich backgrounds in black, red, deep yellow, and dark blue, on which central

pictures of figures, landscapes, or animals, or groups from still life, were executed in bright and lively colouring. Strong and powerful colour contrasts were generally aimed for, as the decorations were usually seen in a very subdued light, coming from the atria, or other chambers, or by lamplight at night, so that, although some of the schemes of Pompeian colouring appeared strong and crude in ordinary light, yet when seen under a low illumination they would be much softened and mellowed. Roman mosaics are generally beautiful in their colour arrangements. Some of the earliest are only in black and white, others are combinations of black, yellow, red, and cream-colour, or vellum-white, the latter being a common and excellent colour scheme for floors. Some splendid colour effects are seen in Roman wall mosaics where the combination consists of brilliant blues, soft purples, yellows, black, and white. A remarkably rich and beautiful complex colour arrangement is seen in the Roman mosaic in the church of Sta. Maria in Trastevere, Rome, consisting of a group of birds and grasses, etc., the ground of which is a dull but warm white, with red in various tones, yellow ochre, and umber tints, cobalt blues, grey-greens of yellowish and bluish tones, and some small portions of a very dark grey. We have not space to describe the many colour harmonies of Roman and Etruscan glass, which equal the best specimens of the Phœnician and Egyptian productions.

The later Greek school of Byzantine art in its many branches might be better described as a renaissance of

Greek colouring, but of a more magnificent order than the latter, since colour was the crowning glory of Byzantine art. The mosaics of Santa Sophia, St. Mark's at Venice, and of many other churches, the silk fabrics, and the enamels, all testify to the Byzantine love of colour.

Sculpture of the human figure was condemned by the early Christians, and all images were forbidden by the Byzantine Church, and so painting found its monumental development in the great mosaic decorations, an art which subsequently led to enamelling on metals, both of which furnished the artist and decorator unlimited scope for colour treatment. Natural colour harmonies were also obtained by the use of porphyry and serpentine marbles, with inlaid work of gold, silver, and precious stones, all of which were employed in the altars, canopies, screens, and pulpits of the churches.

The priest's garments and the hangings of silk were woven in rich colours and tissues of gold. Cornices and capitals richly carved, and full of symbolic ornament, columns and arcades of coloured marbles, and over all, the great vaults and domes glittered and shone with the mosaics of resplendent cherubims, clothed in the brilliancy of colour and gold.

Byzantine artists and craftsmen found their way to Western Italy, and to the Germanic provinces of the Rhine, where they carried their crafts and spread their love of colour. In the valley of the Rhine they founded the Rhenish-Byzantine school of enamellers, whose influence

crept through Italy, and into France, and in time the older cloisonné and champlevé varieties of enamels developed into the translucent variety in Italy, and the painted variety at Limoges, in France.

ITALIAN COLOURING.

The Byzantine mosaics and colouring furnished the themes and colouring of the early Italian painters. At the dawn of the Renaissance, towards the latter end of the thirteenth century (1240–1300), Cimabue, the founder of Italian painting, was strongly influenced in the choice of his subjects and colouring, and even in the pose of his figures, by the Byzantine mosaics. He was the first painter, however, that shook off, in his work, some of the stiff and angular characteristics of the Byzantine school. His subjects, though decorative and of a monumental character, are treated in a softer and more natural manner than those of his predecessors. His work, and that of his more capable pupil, Giotto, strongly influenced the work of the Italian mosaicists of the period, and many designs were made by these two painters for mosaic decoration.

Byzantine and Romanesque design in painting, mosaic work, and in the illuminated missals had deteriorated very much, and the colour in these works had developed into dull and heavy tones, in the centuries preceding the period of Cimabue and Giotto, but afterwards and onwards, to the culmination of the Renaissance in the sixteenth century,

colour and design developed in a steady but decided manner in Italy, owing to the study of the early medieval and classical remains of ancient art, and to a closer study of nature.

The connection of Venice with the markets of the East, the showy and ceremonial life of the Doges, the state assemblies, pageants, and processions, the church of St. Mark's with its splendid decorations, the general prosperity of the governing classes, and their lavish patronage of art, all tended to foster and develop the expression of magnificent colour in all kinds of decoration, and more especially in pictorial art. Giovanni Bellini was the first colourist of his time, but his fame was very much eclipsed afterwards by the work of his celebrated pupils, Titian and Giorgione.

The Venetian painters preferred to work in oil-colours rather than in fresco, although they sometimes executed works in the latter medium, but they doubtless found that they could obtain much finer results in the way of richness, depth, and purity of colour, by the use of an oil, or varnish medium. We shall notice the work of the Venetian painters later on, but here it will be advisable to give a short description of the general colour arrangements of the works of some Italian painters from the fourteenth to the sixteenth centuries.

Beginning the Tuscan school with the painter Duccio (1339), we find that the general colour arrangement of his works was yellow, pink, pearl-grey, and gold. Fra Angelico (1387–1455), another Tuscan painter, used very clear and

bright tones in his draperies, his favourite colours being ultramarine, vermilion, pink, yellow-green, blue-black, brown, and purple, on gold grounds. The lights of his draperies are generally warm in tone, except on the brown drapery, which has cool lights, the purple ones having reddish lights. Benozzo Gozzoli (1420-1498) was a pupil of the former painter, and his works are also painted in pure and lively tones. An original and interesting combination of colours is found, chiefly in the architectural portions of some of his pictures, which consisted in the use of pale pink, vermilion, pure blue, and deep buff, or fawn colour. His colouring was always of a light and cheerful character, and extremely decorative. Lorenzo di Credi (1449–1536), the Florentine painter, is noted for his use of clear tones of yellow-red, yellow, apple-greens, and bright slate-blues. In the majority of the paintings of the Tuscan school the balance of colour is, blue, occupying the greatest area, reds of deep crimson have the medium position, in area, and the yellows, going into amber shades, occupy the least amount of space; the warm yellow flesh tones account for some of the yellow space. The work of Botticelli (1447–1510) is generally distinguished by fanciful and highly decorative colour schemes; soft whites, reds, and citron greens, with umber tones heightened with gold, are the prevailing colours, and which were usually interchanged, so as to give an effect of even distribution of colour.

An exceedingly rich colour harmony may be seen in a picture in the National Gallery by Cosima Tura (1420–1495),

the colour combination being, ultramarine, yellow-green, plum-violet, and deep coral red, which has the effect as if seen through pale amber glass; this is probably due to age and varnish, but the mellow richness of tone is very charming.

The splendour of Venetian colour is proverbial, and the two greatest colourists of that school were Titian and Giorgione, before mentioned as the pupils of Bellini. Giorgione (1477–1511) died young, and his remaining works are very few, but the beauty of their colour is remarkable. A deep underglow of rich and luminous colour is strongly characteristic of his painting. It is difficult to say, if he had lived longer, whether he would have surpassed Titian as an artist and a colourist, but his work showed every promise of his equalling the latter painter if his life had only been spared.

Titian (1477–1576), who lived to the age of ninety-nine, has left a great number of splendid examples of his powers, and as a colourist he has never been excelled. The blues, reds, and yellows of his draperies are of the deepest and purest quality, that glow with lustrous effects of pulsating harmonies. No painter of his time has married the normal red and blue so well together, and he was never afraid of placing these contrasting colours side by side.

In the *Bacchus and Ariadne* of the National Gallery we possess one of the finest of Titian's colour harmonies. The amber-orange and blue draperies of the girl with the cymbals, in this picture, is an exceedingly happy combination. The deep and pale rose, and crimson tones of the other draperies, warm flesh tones, the white,

black, blue, rich browns, olive-greens, and silver-greys of trees, earth, animals, sky, and sea, all blend together in a joyous harmony.

In some pictures by Titian and by Tintoret—another great Venetian colourist—where masses of bright red and blue, in draperies, are placed close to each other, we find that in each colour the lights incline to yellow, so that those of the blue draperies are of a warm greenish tone, and those of the red are of a light orange-yellow tone, the purer colour of the blue or red being found in the middle tones, and the half-tones, and shadows in the blue inclining to violet, and in the red to purple. The beautiful liquid lustre effects in the colours used by these painters, were generally obtained by glazing with very thin and pure transparent colours.

If we compare the arrangement of red and blue in the draperies of some of the later Italian painters, as Guido Reni, for example, in whose works this combination appears cold and repelling, with the use of the same colours by Titian or Tintoret, it will be seen that in the work of Reni all of his lights are too cold and unnatural, owing to an excess of pale cold blues in the lights of the blue draperies, and not enough yellow in those of the red hue.

Rubens (1577–1640) may be ranked as the greatest colourist of the Flemish school, whose best works are remarkable for their warm and transparent colouring, and Rembrandt holds the same position among the painters of the Dutch school.

Though many good colourists in pictorial and decorative art have been found in the Continental and English schools during the eighteenth and nineteenth centuries, there has been no school of colourists yet formed that has equalled the Venetian of the sixteenth century in the splendour and beauty of colour.

In France, the painters Claude Lorraine and Corot have excelled in producing the opalescent-like effects of nature in landscape, and likewise Puvis de Chavannes, in his combinations of grey-greens and silver tones arranged in decorative harmonies, each of whom had a marked individuality of a high order, and a keen sense of the more subtle beauties of delicate colour.

In England, to mention only a few names, we may safely place Turner and Millais as interpreters of nature, and Rossetti and Burne-Jones, in ideal art, with the best colourists of ancient or modern times.

APPENDIX

I.

LIST OF THE PRINCIPAL COLOURS IN ORDINARY USE, SHOWING THE NATURE OF THEIR CHEMICAL COMPOSITION.

White	Flake white	White lead.
	Chinese white	Zinc oxide.
	Cremnitz white	White lead.
	Tin white	Tin binoxide.
	Permanent white	Barium sulphate.
Yellow	Cadmium yellow	Cadmium sulphide.
	Chrome yellow	Chromate of lead.
	Lemon yellow	Barium chromate. Strontium chromate.
	Yellow ochre	Ferric hydrate and clay.
	Mineral yellow	Lead oxychloride.
	Naples yellow	Oxides of lead and antimony.
	King's yellow	Arsenic sulphide.
	Indian yellow	Euxanthate of magnesia.
	Aureolin	Nitrate of potassium and cobalt.
	Gamboge	*Gokathu* gum-resin.
	Raw sienna	Ferruginous earth.
	Italian pink Yellow lake	Quercitrine and alumina.
	Transparent gold ochre	Ferric hydrate and clay.
	Zinc chrome	Chromate of zinc.
Red	Vermilion	Sulphide of mercury.
	Red lead	Lead oxide.
	Venetian red	Sesquioxide of iron.

*

Red	Light red	Calcined Oxford ochre.
	Indian red	Ferric peroxide.
	Iodine scarlet	Mercuric iodide.
	Mars red	Ferric ochre (artificial).
	Red chrome	Chromate and oxide of lead.
	Carmine	Cochineal and alumina.
	Crimson lake	Cochineal with more alumina.
	Scarlet lake	Crimson lake and vermilion.
	Rose madder, or Madder lake, Madder carmine	The colouring matter of the plant *Rubia tinctorium* with alumina.
	Alizarin scarlet	From anthracene, a coal-tar product.
	Indian lake	Lac resin and alumina.
Blue	Ultramarine (genuine)	Sodium sulphide and sodium thiosulphate from the lapis-lazuli.
	Ultramarine (artificial)	Silicate of aluminium and sodium sulphide.
	Cobalt blue	Phosphate of cobalt and alumina.
	Cerulean blue	Oxide of tin and cobalt.
	Smalt	Silicates of cobalt and potassium.
	Prussian blue	Ferrocyanide of iron.
	Antwerp blue	Prussian blue and alumina.
	Indigo	Vegetable colour from *Indigofera*.
	Intense blue	Indigo rendered more intense.
	Permanent blue	Pale artificial ultramarine.
Green	Emerald green	Arsenite and acetate of copper.
	Chrome green	Chromic oxide.
	Cobalt green	Oxides of cobalt and zinc.
	Verdigris	Basic copper acetate.
	Terreverte	Clay, iron, and manganese.
	Malachite	Hydrated bicarbonate of copper.
	Hooker's green	Prussian blue and gamboge.
	Sap green	Juice of buckthorn berries and wood.
	Oxide of chromium	Anhydrous sesquioxide of chromium.
	Emerald oxide of chromium—Viridian green	Hydrated oxide of chromium and borax.
	Scheele's green	Arsenite of copper.

Orange	Orange chrome	Basic lead chromate
	Orange cadmium	Sulphide of cadmium.
	Mars orange	Artificial oxide of iron.
	Burnt sienna	Raw sienna calcined.
Purple	Purple madder	Madder extract with a metallic oxide.
	Indian purple	Cochineal extract and sulphate of copper.
	Mars violet	Peroxide of iron.
	Violet carmine	Extract of the plant *Anchusa tinctoria.*
	Purple lake	Cochineal and alumina.
Brown	Brown madder	Extract from the root of the madder plant.
	Manganese brown	Manganese dioxide.
	Raw umber	Oxides of iron and manganese and clay.
	Burnt umber	The above when calcined.
	Vandyke brown	Bituminous peat-earth.
	Bistre	Soot from wood-fires.
	Cappagh brown	Peat-earth and peroxide of manganese.
	Cologne earth	Vandyke brown calcined.
	Sepia	Fluid from the cuttle-fish.
	Brown-pink	A citrine colour prepared from the juice of *Rhamnus* berries and alumina.
	Mars brown	Iron and manganese oxides and ochre.
Black	Lamp black	Soot from tar or resins.
	Mineral black	Impure graphite.
	Ivory black	Charred bones.
	Blue black	Charcoal from cocoa-nut and peach-stones, or vine-twigs.
	Black lead	Graphite or plumbago.
	Indian ink	Soot from resins and camphor.

2.

PERMANENT PIGMENTS.

Pigments that are not liable to much change under the influence of light, air, moisture, or sulphuretted hydrogen.

White	Chinese white. Zinc white. Permanent white. Tin white.
Red	Vermilion. Light red. Venetian red. Indian red. Red ochre. Mars red. Madder red.
Orange	Cadmium orange. Burnt sienna. Mars orange.
Yellow	Yellow ochre. Transparent gold ochre. Roman ochre. Aureolin. Raw sienna. Zinc chrome. Lemon yellow.
Green	Oxide of chromium. Transparent or emerald oxide of chromium. Cobalt green. Terreverte. Viridian.
Blue	Genuine ultramarine. Artificial ultramarine. Permanent blue. Smalt.
Purple	Purple madder. Mars violet.
Brown	Raw umber. Burnt umber. Brown madder. Cappagh brown. Cologne earth. Sepia. Manganese brown.
Black	Ivory black. Blue black. Lamp black. Indian ink. Graphite.

3.

Pigments which are liable to be injured by sulphuretted hydrogen, air, and moisture.

White	Flake white. Cremnitz white.
Yellow	Chrome yellows. Mineral yellow. Naples yellow. Italian pink. India yellow. King's yellow. Yellow lake.
Orange	Orange chrome.
Red	Red lead. Iodine scarlet. Red chrome. Carmine. Crimson lake. Indian lake.
Green	Chrome green. Sap green. Hooker's green. Malachite. Verdigris. Emerald green.
Blue	Prussian blue. Antwerp blue. Indigo. Intense blue.
Purple	Indian purple. Violet carmine. Purple lake.
Greenish-brown	Brown-pink.
Brown	Vandyke brown. Bistre.

4.

Pigments liable to injury when in contact with white lead.

Yellow	King's yellow. Indian yellow. Gamboge. Italian pink. Yellow lake.
Red	Iodine red. Crimson lake. Carmine. Scarlet lake. Indian lake.
Green	Sap green.
	Indigo. Intense blue.
Greenish-brown	Brown-pink.

5.

Pigments that withstand the action of lime, and may be used in fresco painting.

White	Lime white.
	Permanent white.
	Tin white.
Yellow	Cadmium yellow.
	Lemon yellow.
	Raw sienna.
	Naples yellow.
	Aureolin.
Red	Vermilion.
	Light red.
	Venetian red.
	Indian red.
Green	Oxide of chromium.
	Emerald oxide of chromium.
	Cobalt green.
	Viridian.
Blue	Cobalt blue.
	Genuine ultramarine.
	French, or artificial ultramarine.
	Permanent blue.
	Cerulean blue.
	Smalt.
Brown	Raw umber.
	Burnt umber.
	Cologne earth.
Black	Ivory black.
	Lamp black.
	Blue black.
	Mineral black.

6.

Pigments that are little affected by heat, and may be used in enamel or glass painting, with a vitreous medium.

White	Permanent white.
	Zinc white.
	Tin white.
Yellow	Naples yellow.
Red	Red ochre.
	Venetian red.
	Light red.
	Indian red.
	Mars red.
	Gold and copper alloy.

Green	Chrome greens. Cobalt green. Oxide of chromium. Gold and silver alloy.
Blue	Cobalt. Cerulean blue. Smalt.
Violet	Mars violet. Cobalt and manganese oxides.
Purple	Manganese oxide.
Orange	Burnt sienna. Burnt Roman ochre. Mars orange. Gold.
Brown	Burnt umber. Manganese brown. Gold. Cologne earth.
Black	Graphite. Mineral black.

INDEX

THE END

Richard Clay & Sons, Limited, London & Bungay